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GRADY TRIPLETT
Editor

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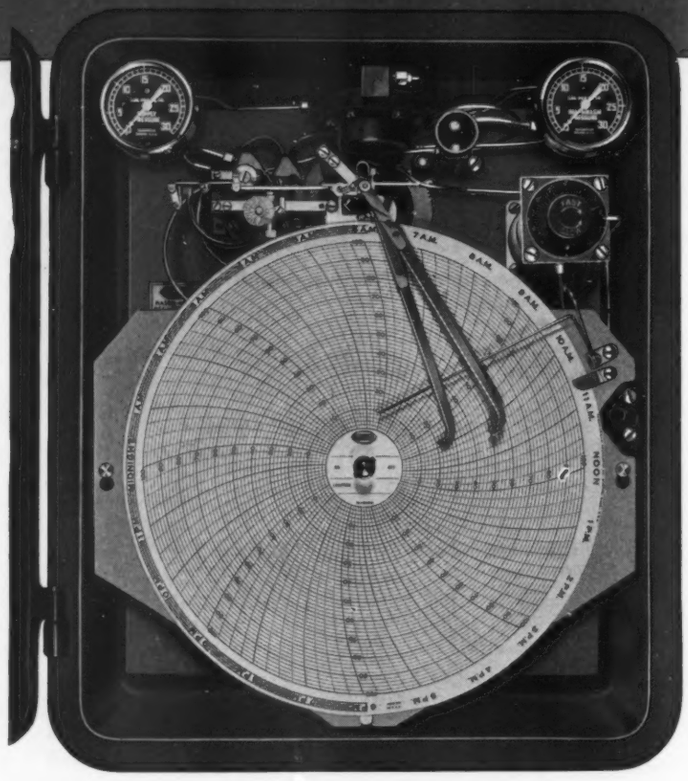

The Recording Controller: Note compactness; simplicity; and accessibility of adjustments. The model shown is the Drift Compensated type.

The Indicating Controller: This single Compensated type is the basic controller. Note the high visibility, air-plane type dials and scale.

MASONEILAN

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VOLUME 19, No. 8 AUGUST, 1940

REFINER
AND NATURAL GASOLINE MANUFACTURER

A Gulf Publishing Company Publication

The Look Box

WHEN difficulty besets an industry the reaction of its man power is disheartening. Then by their complaint they fashion industry as a willful, ruthless force before which men are powerless. It is then that industry threatens to sweep men and institutions into discard.

Men and Excessive Runs

Yet industry, under all circumstances, is only what the thought and action of men have made it. Industry moves not of its own power but by the power men have built into it.

Instead of bemoaning what industry will do to men, men should consider what they have done to industry.

Currently in the petroleum industry men are cringing before the threat of excessive supplies. It is the industry which has fostered a surplus of gasoline. Never is the gasoline stock pile accepted as the result of what men have thought and done. Always, the threat to men comes from what the industry has done.

This attitude is cowardly and the reasoning is in reverse. Only by accepting the surplus as the product of improper management, can solution be found.

Either too much crude oil has been put through stills or the stills have not been so operated that there is better balance betwen gasoline and burning oils. Policy is responsible for the situation in refining.

If too much crude oil has been run to stills, the executives of refineries are responsible, either deliberately or unwittingly. Either is bad management. If too much crude oil continues to be run to stills, the responsibility is with men and not with the industry. The fact that proration orders provide certain allowables or that the Bureau of Mines estimates certain consumption are but admission of bad management, for no governmental body has authority to require either one refinery or all refineries to run fixed throughput.

An approach to solution of the gasoline surplus lies in the flexibility of refining equipment. What comes out of a barrel of crude oil is subject to control. As much as 48.8 percent of it can be converted into gasoline, or as little as 42.3 percent. The one was average gasoline recovery for all plants in the United States in January, 1939, the later was a similar record for May, 1939. As much as 16 percent (the average for February, 1940) can be made into furnace dis-

tillate, or as little as 11.5 percent can be recovered as furnace distillate. Heavy fuel oil may be 23.5 percent or 26.8 percent.

These figures are from actual plant operation for the refining industry in 1938, 1939 and part of 1940. They leave no doubt of flexibility, just as they give no assurance that the flexibility was the result of sound judgment. It seems more likely that flexibility came because of excessive stocks rather than desirable stocks coming out of flexible operation.

If the whole refining industry has such flexibility, any one plant holds possibility of even greater flexibility. It is in looking at one plant that management has its opportunity of stockpile control. So long as one man or one operating committee tremble before a surplus and plead no part in its accumulation, certainly the inanimate industry is beyond control.

Only by making plant operation an individual proposition can there be control of stocks and control of an industry. This is the task for the executive. Someone must determine how much of each grade of merchandise is needed for a season, after which the amount of raw material and the flexibility of equipment can be adapted to reaching the goal. Plant personnel will turn the valves to fit policy.

Defense Before Profit

ALL too frequently in the oil industry is this expression heard:

"Wait until the defense program gets going."

In saying that men admit that they look on the defense program as a means of erasing a gasoline surplus. To them it is an opportunity for profit rather than a burden which may preserve a way of living.

The more the profit hope prevails the less the chance of preserving a way of living. How the money is spent and not the mere spending will determine what it brings in defense. Unfortunately an appropriation is the beginning of defense rather than the end.

Industry, oil included, has a contribution in national defense. It is the duty of men to see that the defense dollar gets the most gasoline and the best gasoline a dollar can provide. When that attitude predominates defense dollars will provide defense.

Sufficient profit to retire investment made solely for defense is permissible and neither government nor the public object to it: But when men look upon the appropriation as a solution for the mistakes that have burdened an industry with too much gasoline, proper spending of the defense dollar is not likely.

Without Regional Restriction

IN concluding his report to the annual meeting of the Pennsylvania Grade Crude Oil Association, J. E. Moorhead, executive secretary, stated the need of the petroleum industry in the United States, although he was talking to but a portion of it. His conclusion was:

"On the face of this record (accomplishments of the association for the year) and in the light of what we all know about the conditions of the market I am not tempted to make any predictions. I do not know what conditions will be six months from now nor what our needs will be then. But I know I am on safe ground in telling you what the greatest need of our industry is now. It is more domestic customers. What happens abroad is on the knees of the war gods. There is not a great deal we can do about it; what little there is to be done we are doing. Our new national defense policy may improve our market later on. But if we are to find a market for the production from the Pennsylvania region wells and the output of Pennsylvania region refiners now we must create more customers and better customers. Now, if ever, is the time to do our utmost."

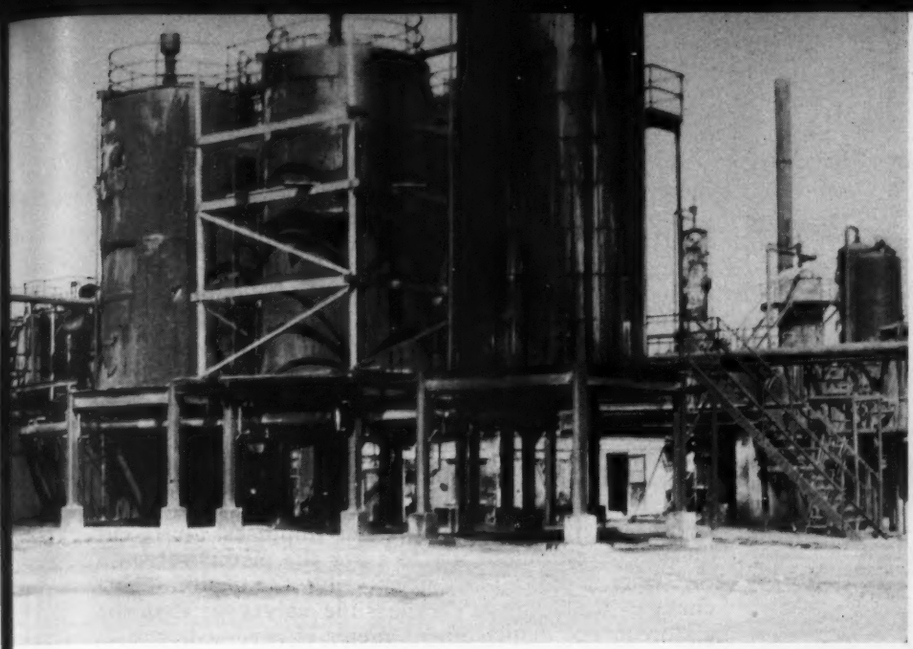
Ear Marked For Roads

THERE is encouragement in the decision of voters of North Dakota who have approved a constitutional amendment which will require that all automotive tax income be used exclusively for road financing. It indicates a proper trend for the tax efforts of the petroleum industry.

Fundamentally what the industry desires is to have the tax on gasoline go into road building and road maintenance. With that such taxes will serve to increase gasoline consumption by providing easier and faster travel.

Fortunately such a restriction will hamper further increases in state gasoline taxes. In too many instances states have increased gasoline taxes for diversion only. Thus the automobile owner has been forced to pay for sea walls, the propagation of oysters, relief and a dozen other activities in no wise connected with highways.

What the industry should do is to concentrate its tax efforts on methods by which voters can pass on constitutional provisions, which will ear mark gasoline and automotive taxes for highway purposes only.



The blending plant for cutting back asphalts with lower boiling point distillates is set in the open, since all working parts are inclosed and regulators are weather proof.

Continuous Automatic Blending for Cutback Asphalts

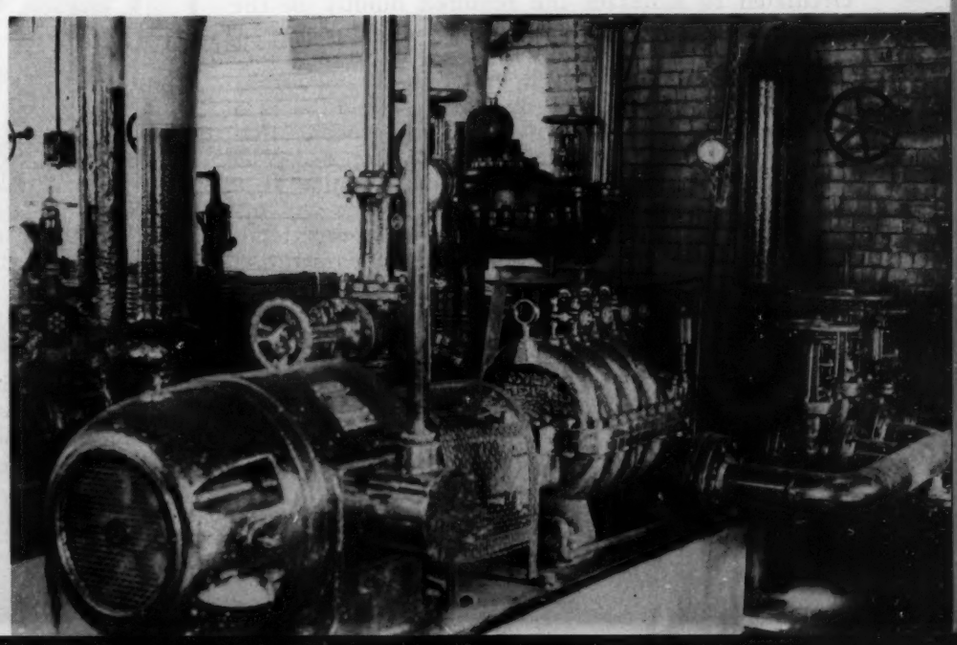
SKELLY Oil Company has installed a continuous automatic blending plant at its El Dorado, Kansas, refining plant for the manufacture of both RC and MC cutback asphalts. The unit has capacity of 500 barrels per hour for blends that may range from 95 percent asphalt and 5 percent solvent to blends of 50 percent of each. Any of the 12 cutback asphalts can be made continuously and without material deviation in viscosity by a single adjustment, which maintains the percent of solvent in the final product.

The plant consists of two related units. The mixing unit consists of a spiral type measuring element inclosed in a cast steel housing, flanged at each end and surrounded by steam heating coils, which in turn are cased with a sheet steel jacket and insulated to prevent dissipation of heat. A meter register at the top indicates production in gallons.

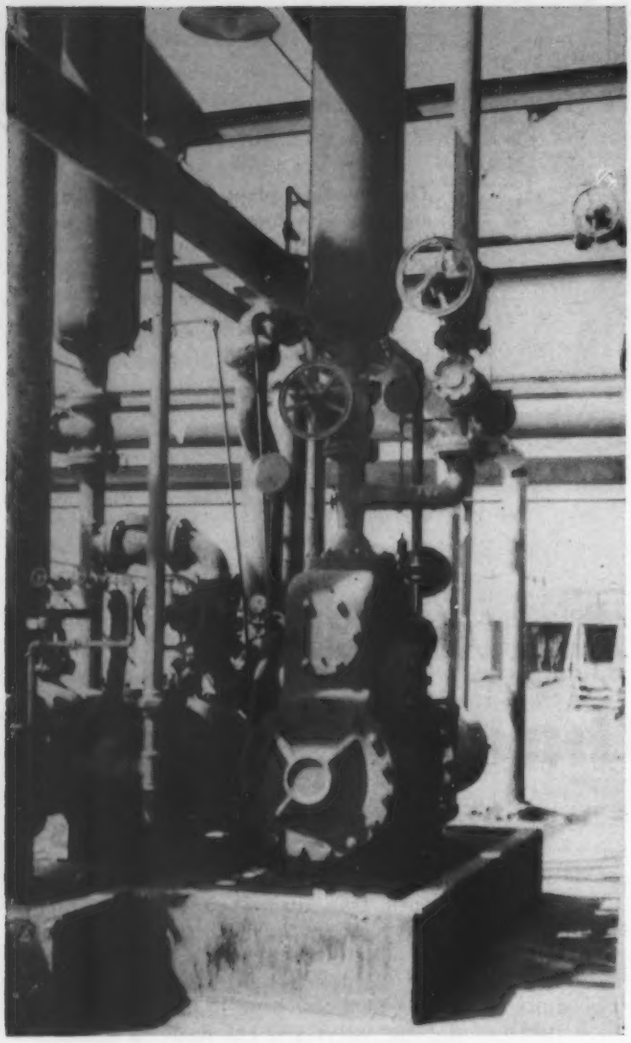
Incorporated within this unit is a device which translates the rotative speed of the meter spindle into power impulses whose frequency is directly proportional to the flow of blend.

This unit is set in a straight pipe line arrangement with a lubricated plug valve cut-off flanged directly on the down stream side, with a flanged T bolted to the up stream side. A second lubricated plug valve is attached to the flanged T so that the entire unit may be removed from the system without disturbing the remainder of the fittings.

Next on the upstream comes a steam-coil-jacketed strainer case with a bolted cover so the strainer element may be removed for cleaning and inspection. This strainer, of heavy perforated steel is to catch large particles of foreign matter which may enter with the asphalt. Large flanged lubricated plug



Solvent is delivered to the displacement meter side of the blending unit by a motor driven centrifugal pump, which can operate against a closed gate, thereby permitting entry of solvent only when the meter on the asphalt unit actuates the displacement meter.



Stroke of the displacement meter is set in inches to introduce solvent in desired proportion. It resembles the steam end of a pump. Air from the metering device on the asphalt unit to the dummy cylinder actuates the piston and introduces solvent into the chamber.

valves, on bolted Ts are attached at each end of this assembly so that the lines, both up and down stream may be drained. The asphalt line is connected to the fittings upstream from the pipe-line strainer, and consists of a jacketed line through which steam is circulated to maintain the required fluidity of the asphalt while it is being cut back.

The second unit resembles a large steamp pump with the fluid end removed. It has bore and stroke of 16 inches. Where the fluid end should be is a dummy cylinder in which is an adjusting device that operates on the threaded end of the piston rod. The construction of this end of this unit is similar to a conventional simplex pump, as slide valves are furnished in the steam chest with a valve stem extending outward through a packing gland. In operation this unit is a displacement meter which measures the quantity of solvent introduced into the asphalt upstream from the blending and mixing meter.

Stroke Adjustment

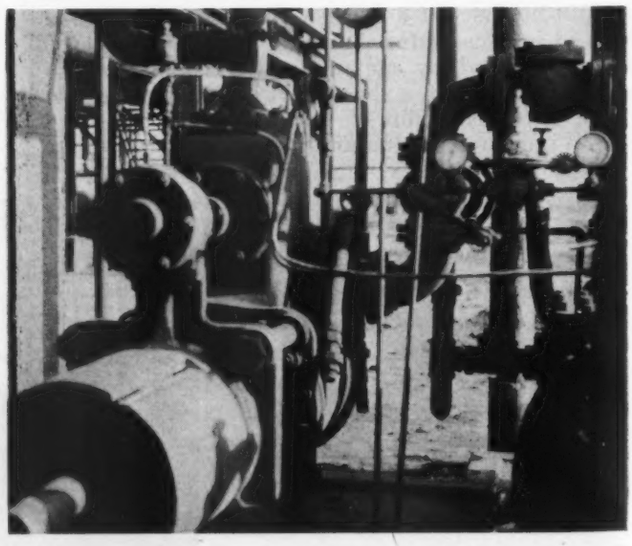
The adjusting device in the dummy cylinder is operated with a crank on a threaded nut moving a scale pointer to adjust the stroke of the displacement meter for any length in inches from zero to 16. The dummy cylinder is slotted on one side where a scale is attached reading the full stroke of the piston. As an example, if the displacement meter is to be operated with a stroke of 6 inches, the adjusting screw is moved in until the pointer registers 6 inches on the scale, and the stroke is permanent until the next change is made.

The device incorporated in the spiral metering section of the blending unit is connected with the plant air supply and to a piston valve on the second unit, which is connected directly to the slide valve stem, so that, as the rotation of the spiral meter spindle is translated into power impulses, air is cut off and on automatically to enter the piston valve on the second unit. The air entering the piston valve changes the position of the slide valves so that the piston in the displacement meter is reversed.

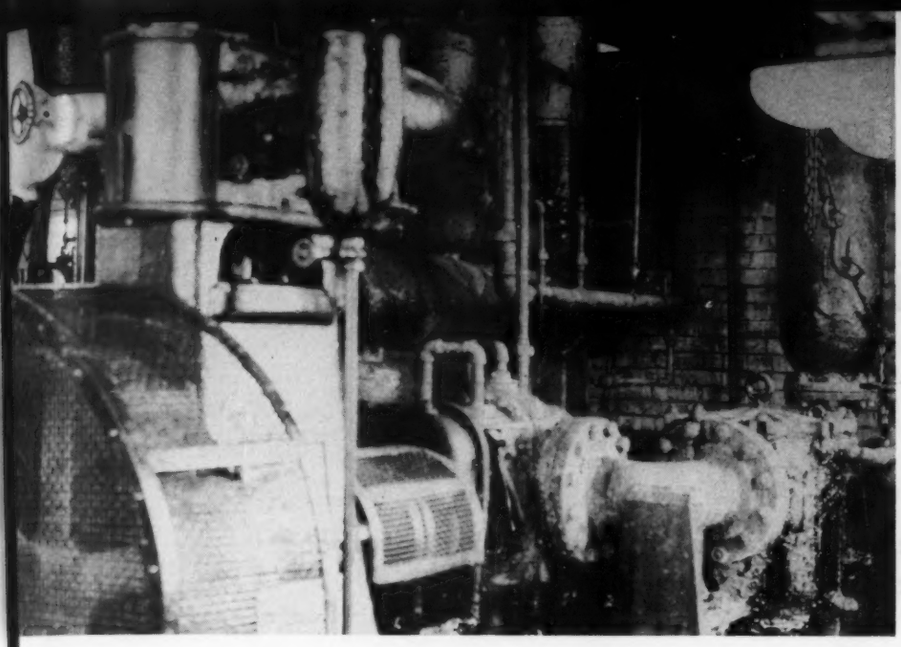
Asphalt is pumped with a gear pump, driven by a vertical steam engine, running at constant speed, through the steam jacketed line to the blend mixing unit. Solvent, either naphtha or gas oil, is pumped to the displacement meter from storage by a 4-stage centrifugal pump, driven by an electric motor. Surge chambers are attached to the discharge line of the solvent pump to absorb the shock of direction change of the piston in the displacement meter. Between the centrifugal pump and the displacement meter is a back-pressure control valve to maintain a constant back pressure on the solvent pump.

Calculations and Adjustments

When preparing for a cutback blend of asphalt and solvent, the proportions of each are calculated in percentages, and the adjusting screw of the dummy cylinder of the displacement meter set at the required stroke that will deliver the correct ratio of solvent to finished cutback. Lines from the metering and blending unit are opened both ways, and the asphalt pump started. At the same time, the solvent centrifugal pump is put in motion, but, as it will continue to operate against a closed gate, it does not



Air actuated dummy cylinder of the liquid displacement solvent unit, whose stroke can be adjusted in inches to assure proper proportion of solvent being delivered for the required cut back blend of asphalt.



Asphalt delivery from tanks to blending unit is through a geared pump, driven by a constant speed vertical steam engine.

deliver solvent until the blend meter starts to operate.

As soon as the rotation of the meter spindle begins, the power imposes bleed air from the device on the meter registered to the piston valve on the dummy cylinder. As the impulses are of sufficient frequency the piston moves the slide valves on the displacement meter cylinder to admit solvent into the chamber. Continuation of the power impulses changes in direction, reverses the flow of air so that the slide valve changes to reverse the motion of the piston in the displacement meter cylinder.

Solvent in the filled side of the displacement meter, unable to escape otherwise, flows through opened ports to the rotative mixing and metering unit in the first section of the plant. Power to move the piston in the displacement meter is suppled by the pressure on the discharge of the solvent centrifugal pump, and the displacement meter piston continues to reciprocate so long as asphalt is pumped to the metering and mixing device from storage.

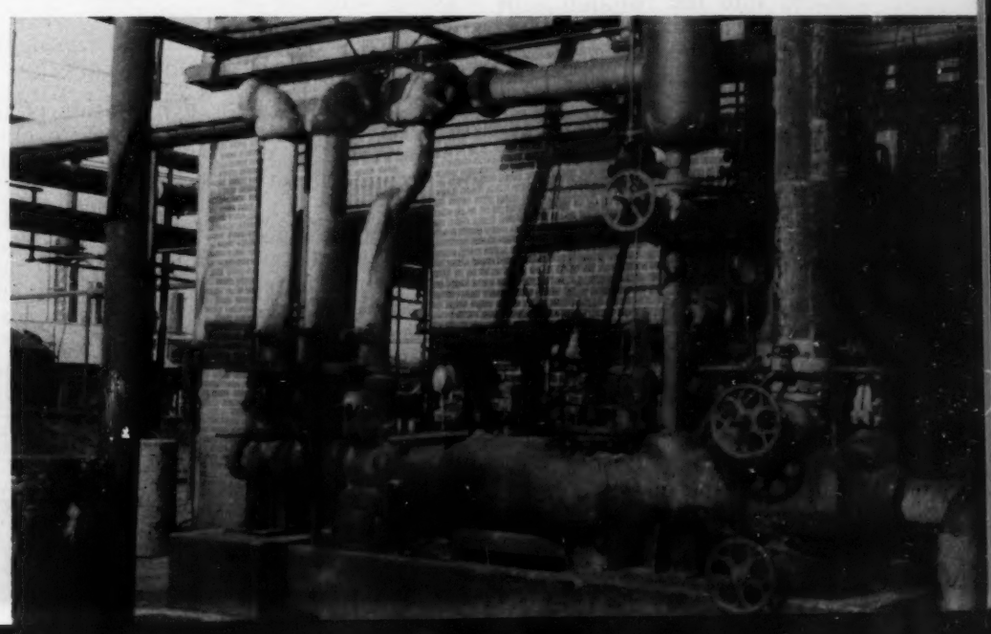
Solvent, on leaving the displacement meter flows through a line connected to the flanged T upstream from the mixing meter, so that the turbulence set up by the two materials passing through the spiral unit completes the blend. If the flow of asphalt is halted for any reason, the movement of the spiral metering device is also stopped which in turn prevents the power impulses to continue that operates the solvent displacement meter.

As in batch blending, there must be the careful attention to proportions of solvent to asphalt, but, as the two are mixed under pressure in a closed system, foaming and loss of lighter fractions are avoided. When the correct proportions have been ascertained, and the plant set to deliver the required quantity of solvent, there is but a slight deviation from specifications at the delivery end of the pipe line. Piping at the discharge end of the mixing unit permits the completed blend to be delivered to storage or to tank cars as required.

With a run for blending gas oil and asphalt for MC cutback, the plant was operated as follows:

Asphalt pump.....225 gallons per minute.
Gas oil pump ..... 70 gallons per minute.
Percentage of asphalt.....77.3%
Percentage of gas oil.....22.7%
Gas oil pump discharge—at pump..110-123 pounds, gauge.
Gas oil stream, after pressure regulator ..... 74- 83 pounds, gauge.
Stroke of gasoline displacement meter .....6½ inches.
Gas oil displacement meter movement .....6 r.p.m.
(Six strike cycles, or 12 displacements of fluid in cylinder ends)
Blend temperature.....260° F.
Blend meter discharge.....42 pounds, gauge.
Samples: taken at same time.
At blending meter discharge:—Saybolt Furol Vis. 308 sec. at 122° F.
At storage tank inlet line meter nipple.
Saybolt Furol Vis. 301 sec. at 122° F.

This would indicate that the variation in blending of the two materials to form a cutback asphalt amounted to only .0227 percent.



Rotation of the spindle in the control meter bleeds air which by impulses is fed to the dummy cylinder of the solvent unit in reversed action so the slide valve moves the piston in the displacement meter cylinder.

Kinetics and Mechanism of Decomposition of Hydrocarbons

A Study of the Inhibiting Effect of Unsaturated Hydrocarbons on the Decomposition of Paraffin Hydrocarbons

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ZHURNAL OBSHCHEI KHIMII
(Journal of General Chemistry) Vol. 9, No. 23, pages 2162-2167, 1939
Translated by J. G. TOLPIN, Gray Processes Corporation

THE effect of certain unsaturated hydrocarbons on decomposition of isooctane was studied. In these studies the following unsaturated hydrocarbons were investigated: ethylene, propene, normal butene, isobutene, 2,2,4-trimethylpentene, bivinyl, cyclohexene and isoprene. It was found that:

1. Diisobutene, normal butene and ethylene exert no noticeable retarding effect on the decomposition of isooctane under atmospheric pressure;

2. Isobutene, propene, bivinyl, cyclohexene and isoprene greatly reduce the decomposition velocity of isooctane;

3. For the case of cracking of isooctane in the presence of propene and bivinyl the dependence was studied of the extent of retardation upon the concentration of the retarding agent. It was established that with rise of the concentration of the retarding agent its retarding effect rises first rapidly and then more slowly;

4. A mechanism is suggested explaining the retarding effect of some unsaturated hydrocarbons on the basis of their ability to combine free radicals.

* * *

This translation is submitted by the Petroleum Division of the American Chemical Society which, however, assumes no responsibility for the facts and opinions presented in this paper, nor does it necessarily endorse statements made therein.

A STUDY of the cracking velocities of paraffins from ethane to dodecane shows in all cases a sharp decrease of the cracking velocity constant calculated by the equation for reactions of the first order with rise of the extent of decomposition.[1, 2, 5, 6] Cracking of oil products does not give any clear picture with respect to the dependence of the cracking velocity upon the extent of decomposition. Some oil fractions show a sharp decrease of the velocity with the progress of decomposition while for others the velocity preserves an approximately constant value up to 60 percent decomposition.

In a study of the kinetics of decomposition of lower paraffins under low pressures it was shown in some individual cases that the reactions are retarded by the reaction products. Dintses and Frost[1] showed that decomposition of propane in the presence of freshly formed products of its decomposition takes place from the very beginning at a considerably lower rate than decomposition of pure propane.

A study of the effect of different additions on the decomposition velocity of ethane[2] showed that hydrogen, methane, ethylene and normal butene introduced into the reaction zone together with ethane produced no marked retarding effect on the cracking velocity of the latter. However, when the cracking of ethane begins in the presence of propene the latter exerts a considerable retarding effect and this increases with rise of its concentration up to 10 percent. With further rise of the concentration of propene its retarding effect on the decomposition of ethane is not observed.

The writer carried out a study of the effect on the decomposition of isooctane (2,2,4-trimethylpentane) of additions of ethylene, propene, normal butene, isobutene, 2,2,4-trimethylpentene, bivinyl, cyclohexene and isoprene. The isooctane was prepared at the Khimgaz plant by hydrogenation of diisobutene over molybdenum sulfide. Diisobutene was obtained from cracked gases by the cold sulfuric acid method. Ethylene, propene and isobutene were obtained by dehydration of the corresponding alcohols with sulfuric acid; cyclohexene and isoprene were prepared by distillation of Kahlbaum preparations.

The study of the decomposition was carried out in glass coils (tungsten glass) in a lead bath. The temperature of the lead bath was measured by means of a platinum—platinum-rhodium thermocouple and was accepted as the reaction temperature. Before entering the reaction coil the product was passed through a preheater where it was heated to a temperature approximately 100° lower than the cracking temperature. The reaction products were passed through a cooler and collected in a burette if liquid and in a gasometer if gaseous. The dissolved gas was

TABLE 1
Effects of Additions on the Cracking Velocity of Isooctane

ADDITIONS	Concentration of the Addition	Temperature of the Experiment	Sec.	Decomposition Calculated from the Amount of Gas, Percent	K_1, from the Amount of Gas	Decomposition, from the Undecomposed Isooctane Percent	K_1, from the Undecomposed Isooctane
	.....	550	13.4	17.5	0.0143	.....	.....
	.....	550	9.5	13.5	0.0152	.....	.....
	.....	549	9.2	11.9	0.0132	12.0	0.0132
None	.....	548	10.2	12.2	0.0125	11.5	0.0119
	.....	550	76.5	39.7	0.0066	.....	.....
	.....	548	51.4	33.6	0.0079	29.5	0.0068
Diisobutene	10% by vol.	550	11.4	16.0	0.0150	.....	.....
Diisobutene	6% by vol.	550	11.6	18.8	0.0180	.....	.....
Normal butene	12% mole	550	13.4	20.4	0.0170	.....	.....
Normal butene	20% mole	550	10.7	17.2	0.0176	.....	.....
Isobutene	16% mole	550	13.2	14.2	0.0115	.....	.....
Isobutene	16% mole	550	14.0	15.3	0.0118	.....	.....
Propene	5% mole	550	11.5	13.8	0.0130	.....	.....
Propene	9% mole	550	11.8	8.8	0.0088	.....	.....
Propene	21% mole	550	12.0	8.5	0.0078	.....	.....
Bivinyl	2.5% mole	550	11.8	11.4	0.0125	.....	.....
Bivinyl	5% mole	550	12.2	9.3	0.0080	.....	.....
Bivinyl	5% mole	550	93.7	35.0	0.0046	.....	.....
Bivinyl	10% mole	550	14.8	9.3	0.0066	.....	.....
Bivinyl	10% mole	550	11.5	8.0	0.0076	.....	.....
Bivinyl	10% mole	550	45.3	22.4	0.0056	.....	.....
Bivinyl*	11% mole	550	17.1	11.5	0.0071	10.5	0.0065
	10% mole	550	20.3	.....	.....	9.5	0.0049
Cyclohexene	10% by vol.	548	10.5	7.1	0.0069	.....	.....
	10% by vol.	548	10.3	7.2	0.0073	7.0	0.0070
	10% by vol.	548	46.0	27.4	0.0069	21.2	0.0052
	10% by vol.	548	43.0	26.9	0.0070	26.9	0.0073
Isoprene	10% by vol.	548	11.9	10.6	0.0094	8.0	0.0070
	10% by vol.	548	51.0	25.5	0.0057	24.0	0.0054
Ethylene	7% mole	548	9.2	11.3	0.0180	9.0	0.0102
	15% mole	548	8.5	14.0	0.0177	8.8	0.0108

* Charged in the form of gas.

distilled off from the liquid condensate and added to the eliminated gas.

In the cases in which the addition under investigation was a liquid product (trimethylpentene, cyclohexene, isoprene) it was added to the isooctane to be cracked and the mixture charged from the burette into the preheater. Bivinyl was charged in the form of its solution in isooctane. The other gaseous additions, ethylene, propene, etc., were charged into the preheater simultaneously with isooctane in the form of gas. The rate of their flow was regulated by means of a flow meter. The contact period was calculated from the average rate of flow of the products into the reaction coil at the inlet and the outlet from it.

The percent decomposed was calculated from the ratio of the number of moles of gaseous paraffins obtained from cracking to the number of moles of isooctane used. This method of calculation is based on the fact that according to the Rice theory[3] in the primary decomposition (at the extent of decomposition not exceeding 15 percent) one paraffin molecule produces always only one saturated molecule of the decomposed product (paraffin or hydrogen). This conclusion was verified by Dintses and Frost[7] who showed its correctness and established that the product obtained as a result of slight cracking under atmospheric pressure do not contain more than 4 carbon atoms. It is seen from Table 1 that the correctness of this calculation is confirmed in all cases by the calculation of the percent of decomposition from the amount of unchanged isooctane.

Each of the hydrocarbons added to isooctane was cracked in preliminary experiments in pure state under the same conditions as used for its mixture with isooctane. In the calculation of the percent decomposition of isooctane from the total number of saturated gaseous molecules obtained in cracking of the mixture the number of saturated molecules corresponding to the addition was subtracted. The

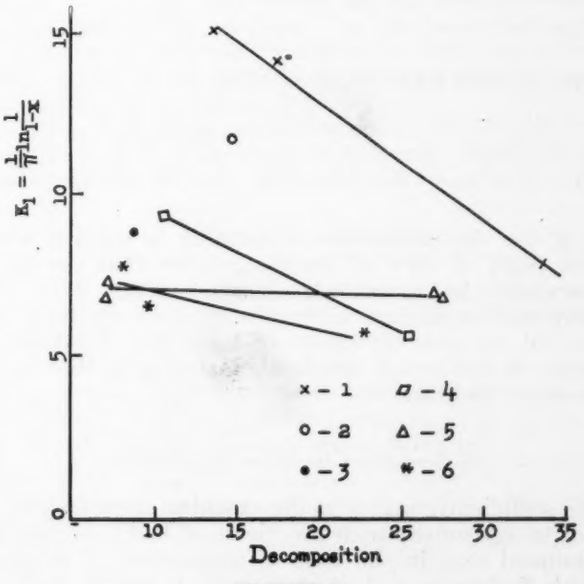


FIGURE 1
Effect of different additions on the cracking velocity of isooctane.
1—pure isooctane; 2—with isobutene; 3—with propene; 4—with isoprene; 5—with cyclohexene; 6—with bivinyl.

TABLE 2
Effect of Bivinyl on the Cracking Velocity of Normal Octane

SUBSTANCE	Temperature of the Experiment	Sec.	Decomposition in Percent	K_1 from Gas
Normal octane	552	7.4	17.5	0.0259
Normal octane + C_4H_6	552	7.4	10.2	0.0145
Normal octane	552	3.57	7.5	0.0218
Normal octane + C_4H_6	552	3.64	3.0	0.0158*

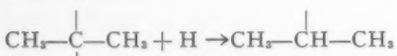
* 10 mole percent bivinyl added.

results of the experiments are reported in Table 1 and Fig. 1. The cracking velocity constant K_1 was calculated according to the equation

$$K_1 = \frac{1}{\tau} \ln \frac{1}{1-x}$$

It is seen that while diisobutene, normal butene and ethylene exert no noticeable retarding effect on the decomposition of isooctane the presence of isobutene, propene, bivinyl, cyclohexene and isoprene greatly reduces the cracking velocity of isooctane.

A. V. Frost[8] explained the observed phenomena by a mechanism based on the assumption that active radicals (serving according to Rice as transfer agents of the chain) are combined by molecules of unsaturated hydrocarbons forming radicals of low activity. The combination of active radicals with formation of inactive radicals is regarded as rupture of the chain. The mechanism of combination of active radicals as suggested for the case of propene is as follows: hydrogen, methyl and ethyl radicals interact with the middle carbon atom, the hydrogen of which migrates to the extreme carbon atom



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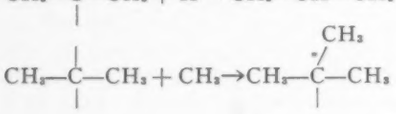

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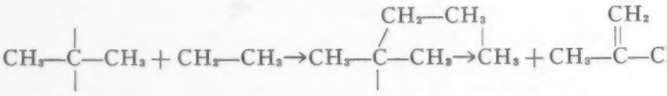
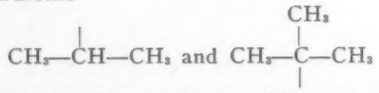


(4)

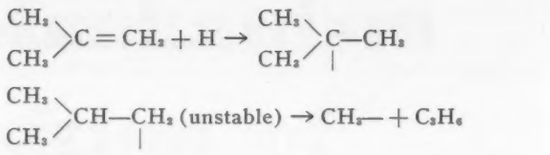
If the decomposition of radicals is studied from the point of view of the assumption that the bond between the unsaturated carbon atom with the neighboring atom is strengthened, and the bond removed by one carbon atom from the unsaturated atom is weakened and further assuming that symmetrical radicals

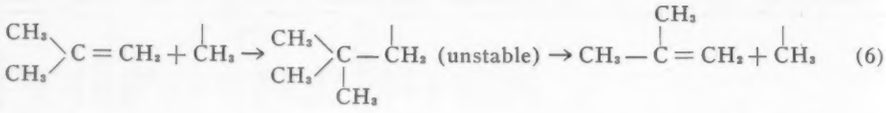


are sufficiently stable in the cracking zone (which is not in agreement with the views of Rice), it may be assumed that in the case of interaction of propene with hydrogen and methyl radicals stable radicals are formed due to disappearance of a part of the transfer agents of the chain which brings about a retardation of the reaction. In the case of interaction of propene with ethyl radical no stable radical is formed since the latter may decompose splitting off the methyl radical at the bond removed by one bond from the carbon atom with the free valence (equation 4).

Bivinyl should interact with radicals in a completely analogous way. Unlike propene bivinyl has two carbon atoms capable of a stable combination with radicals (methyl and atomic hydrogen) so that its retarding effect should be stronger than the effect of propene.

Isobutene can combine in a stable way only atomic hydrogen.





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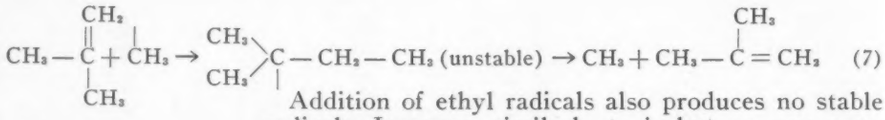
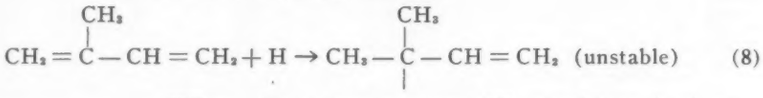


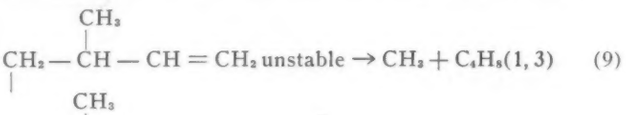
(7)

Addition of ethyl radicals also produces no stable radicals. Isoprene, similarly to isobutene, can combine only hydrogen atoms



(8)

When the extreme atom (8) combines hydrogen a stable radical is formed since the bond removed by one carbon atom from the unsaturated atom is a double bond. When other atoms combine hydrogen radicals are formed that are decomposed as follows:



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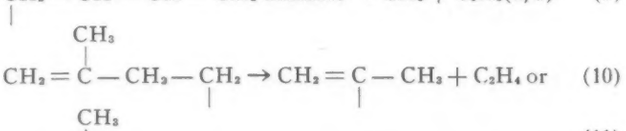

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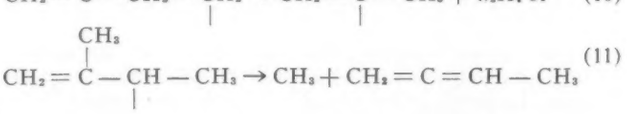

(11)

The chain is broken when radicals are formed that decompose according to equation 10 since as a result of the decomposition the transfer agent of the chain is not regenerated. When radicals are formed decomposing according to equations 9 and 11 the transfer agent of the chain (CH_3) is regenerated. Since isoprene can combine atomic hydrogen by means of two carbon atoms while isobutene can combine it only by means of one atom the retarding effect of isoprene should be higher than that of isobutene.

Addition of a methyl group to isoprene leads in no case to formation of stable radicals. Consequently, the retarding effect of isoprene is weaker than that of propene or bivinyl.

On the basis of the above it may be assumed that of the four mentioned reagents the highest retarding effect is due to bivinyl, a somewhat lower to propene, then follow isoprene and finally isobutene. Normal butenes and diisobutene cannot combine in a stable way the active radicals according to the above scheme. All above assumptions were experimentally confirmed as shown by Figure 1 and Table 1.

The dependence of the extent of retardation upon the concentration of the retarding agent was studied in the cases of propene and bivinyl. The results are given in Figure 2. The same picture is observed as noted previously by Dintses and Frost. With rise in concentration of propene and bivinyl their retarding effect on the decomposition of isooctane increases first rapidly and then slower. Thus, Figure 2 illustrates that when the concentration of propene rises from 0 to 10 percent the decomposition velocity

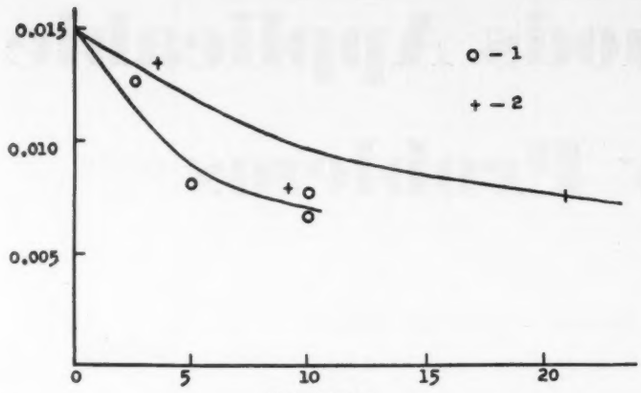

FIGURE 2

Dependence of the cracking velocity of isooctane upon the presence of bivinyl and propene.

1—bivinyl; 2—propene.

constant of isooctane is reduced to 50 percent. With further rise of the concentration of propane from 10 to 20 percent it decreases only by 20 percent.

A similar conclusion may be drawn from a study of the effect of bivinyl on the decomposition of isooctane. A comparison of the curves 1 and 2 in Figure 2 shows that in order to attain the same retarding effect the concentration of propene should exceed the concentration of bivinyl which is in agreement with the above mechanism of combination of free radicals by unsaturated hydrocarbons.

The retarding effect of bivinyl was verified also on the decomposition of normal octane and the results are given in Table 2.

The effect of bivinyl in the cracking zone on the composition of gaseous cracked products was studied by precise low temperature rectification of cracked gases by a method similar to that of Podbielniak analyzing the separate fractions. It was applied to cracking of normal octane and isooctane in pure form and in mixture with bivinyl. The results given in Table 3 show that while causing a reduction of the cracking velocity of the two octanes bivinyl influences very little the composition of the cracked products.

TABLE 3

Effect of Bivinyl on the Composition of the Products of Cracking of Normal Octane and Isooctane

Obtained	PERCENT BY VOLUME					
	Normal Octane	Normal Octane + C_4H_6*	Isooctane		Isooctane+C_4H_6 (10% by volume)	
H_2	4.9	6.0	10.4	12.1	6.5	8.4
CH_4	21.6	20.6	23.6	24.9	29.0	20.8
C_2H_6	14.4	13.5	5.0	0.6	2.4	5.7
C_3H_8	2.9	3.7	4.9	1.0	6.2	3.6
C_4H_{10}	0.0	0.0	0.0	3.7	0.0	0.0
C_2H_4	28.5	29.0	4.2	3.7	2.8	5.8
C_3H_6	16.7	15.5	9.1	11.8	11.8	13.7
C_4H_8	10.7	10.5	41.0	41.5	38.2	38.0
C_5H_{10}	0.3	1.2	1.8	0.6	2.5	4.0

* 10 percent by vol.

The retarding effect of bivinyl was verified also on the decomposition of normal octane and the results are given in Table 2.

This seemingly strange fact is easily conceivable when the following is considered. According to the calculation of Rice and Herzfeld[4] the average length of a chain in decomposition of ethane is 100. A chain of close length should be observed also in the case of other hydrocarbons. In accordance with rules governing chain reactions $\gamma = 1/\beta$ or if β is expressed in percent

$$\gamma = 100/\beta \qquad (12)$$

in which γ is the average chain length; β the probability that the transfer agent of the chain of the free radical will be destroyed.

It follows from the equation 12 that if the average chain length is 100 the amount of free radicals destroyed as a result of chain rupture will be 1 percent. In order that the velocity of a chain reaction is diminished by half as observed in cracking of isooctane in the presence of bivinyl it is necessary that the average length of the chain be diminished by half, i.e., in the present case it would be equal to $100 \div 2 = 50$. In this case β will amount to 2 percent. Of 100 radicals causing decomposition of molecules only 2 are combined by the retarding agent. This low amount can naturally not exert any noticeable effect on the composition of the reaction products determined by analysis.

This study was carried out under the supervision of A. V. Frost to whom the writer expresses her thanks.

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Graphical Methods Applicable to Refinery Problems

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GRAPHICAL methods of calculation are a great aid in the solution of many problems encountered in the design of petroleum refinery equipment. Many complex problems, which are impossible to handle analytically, can be easily treated graphically. Functions, incapable of analytical expression, can be plotted and then integrated or differentiated as the need may be. Instead of using average values for different factors, point conditions may be employed to give more accurate results.

An understanding of only the basic fundamentals of differential and integral calculus are necessary for the graphical solution of involved differential equations.

Two simple "rules" cover all of the calculus required for most calculations, (1) the slope of a curve at any point is the differential of the function at the values of the variables indicated by the coordinates of that point, (2) the area bounded by two ordinates, the curve and the X-axis is the integral of the function between the limits of the abscissa. This area is commonly referred to as the "area under the curve." A convenient method of plotting integral and differential curves is to plot the integral above the differential employing identical scales for the abscissa.

The relationships existing between enthalpy and heat capacity may be used as an example. If the molal enthalpy, above some arbitrary base, is plotted against the temperature, the slope of this curve represents the molal heat capacity of the material at the indicated temperature. It follows that the integral of the molal heat capacity between selected limits of temperature will be the change in enthalpy between these limits. The curves in Figure 1 illustrate these principles. The molal heat capacity of buetane vapor at one atmosphere has been plotted against temperature in the lower curve and the molal enthalpy, above vapor at 50° F., in the upper. This may be readily shown to be dimensionally correct.

	Units	Dimensions
Molal heat capacity	$\frac{\text{B.T.U.}}{\text{Lbs. Mole °F}}$	$\frac{H}{MT}$
Molal enthalpy	$\frac{\text{B.T.U.}}{\text{Lbs. Mole}}$	$\frac{H}{M}$

It is obvious that the dimensions and units of the area O a b c, $\frac{H}{MT} \times T$, are $\frac{H}{M}$, $\frac{\text{B. T. U.}}{\text{Lbs. Mole}}$ respectively and the change in enthalpy is therefore identical with the integral of the molal heat capacity curve.

Using the smallest squares as the basic unit of area, a careful check will show that there are approximately 218 of these squares in the area considered. The area in the squares cut by the curve can be estimated as fractions of squares or by pairing off partial squares which appear to equal a unit. The "area" of one of these unit rectangles is, on this plot, 10.0 B.T.U. per pound mole since the height is 2.0 B.T.U. per pound mole degree Fahrenheit and the base is 5.0° F. The total area or integral between 50° F. and 140° F. is therefore 2180 B.T.U. per pound mole. This area is identical with the change in enthalpy between these temperatures.

Various methods of determining slopes and areas may be employed. By making the usually justifiable assumption that, over a short interval, a curve may be considered a straight line, the slope can be easily calculated. The ratio of the change in ordinate to the change in abscissa may be regarded as equal to the slope. This approximation may be expressed as $\frac{\Delta y}{\Delta x} = \frac{dy}{dx}$. The magnitude of the slope may be plotted for the abscissa representing the midpoint of the interval. The shorter the radius of curvature, the shorter the interval must be in order to maintain the same degree of accuracy.

A simple method of determining the slope is to draw a straight line tangent to a curve and then determine the point of tangency by inspection. This method is rapid and as accurate as the other methods in most cases.

A convenient method of determining the slope of a curve at a point is by the use of a metal mirror. A slight displacement of the line results if a glass mirror is used because of the impossibility of drawing the line at the reflecting surface. When the mirror is held with its edge on the paper and with the reflecting surface normal to the curve, the reflection of the curve will appear as a smooth continuation of the actual curve. A line drawn using the mirror as a straight edge will be the normal to the curve. A perpendicular to the normal, constructed by means of the mirror, is parallel to the tangent to the curve, at the point of intersection of the normal and the curve.

The slope of the tangent may be calculated from that of the normal. The basic relationship is that the slope of tangent is the negative reciprocal of the slope of the normal, but this applies only to the apparent slopes of these lines. The apparent slope may be defined as the tangent of the angle made by the intersection of the line with the X-axis. This angle is obviously a function of the ratio of the scales used in plotting the curves. If the ratio is 1.0, the true and apparent slopes are identical, the true slope being the value of derivative. In the example selected, 1 inch on the X-axis represents 50° F. and 1 inch on the Y-axis, 2000 B.T.U. per pound mole. The ratio, is 40.0 B.T.U. per pound mole degree Fahrenheit. The apparent slope of the normal constructed at 190° F., point d in Figure 1, is —1.43. The negative reciprocal

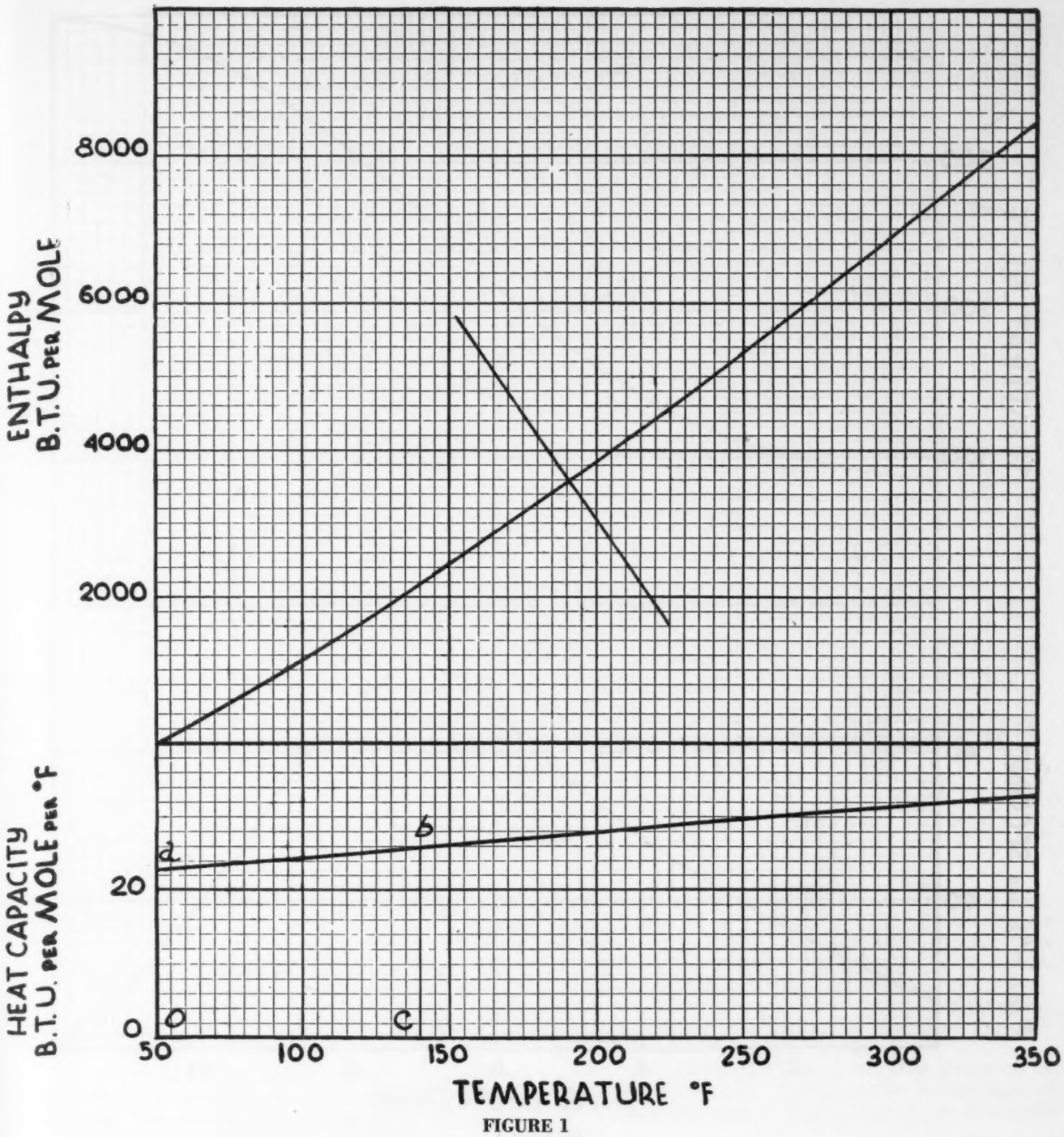

FIGURE 1

of this is .70 and the true slope of the curve at this point is .70 x 40.0 or 28.0 B.T.U. per pound mole degree Fahrenheit. The ordinate of the heat capacity curve at this temperature is 27.8 B.T.U. per pound mole degree Fahrenheit.

Differentiation of the time temperature curve shown in Figure 2 illustrates several of the principles involved in a graphical treatment of this type. Inspection of the upper curve shows that when θ equals zero the slope is small and that it steadily increases until the inflexion point is reached at approximately 7.0 seconds. The slope then decreases from the maximum at the inflexion point to almost zero when θ equals 12.0 seconds. Thus the general slope of the differential curve can be determined by inspection. It is usually desirable to plot the differentials because the effect of individual errors is minimized when a smooth curve is drawn through the points.

Values of the differential as determined by drawing tangents to the curves are listed in the following table.

TABLE 1
Slope of Heating Curve

θ —	2.0	4.0	6.0	7	9	10	11
$\frac{dt}{d\theta}$ —	14	28.	46.	51.	34.	10	9

Where the time is expressed in seconds and the rate in degrees per second.

The differential curve may be checked by integration to determine whether or not such integration will repro-

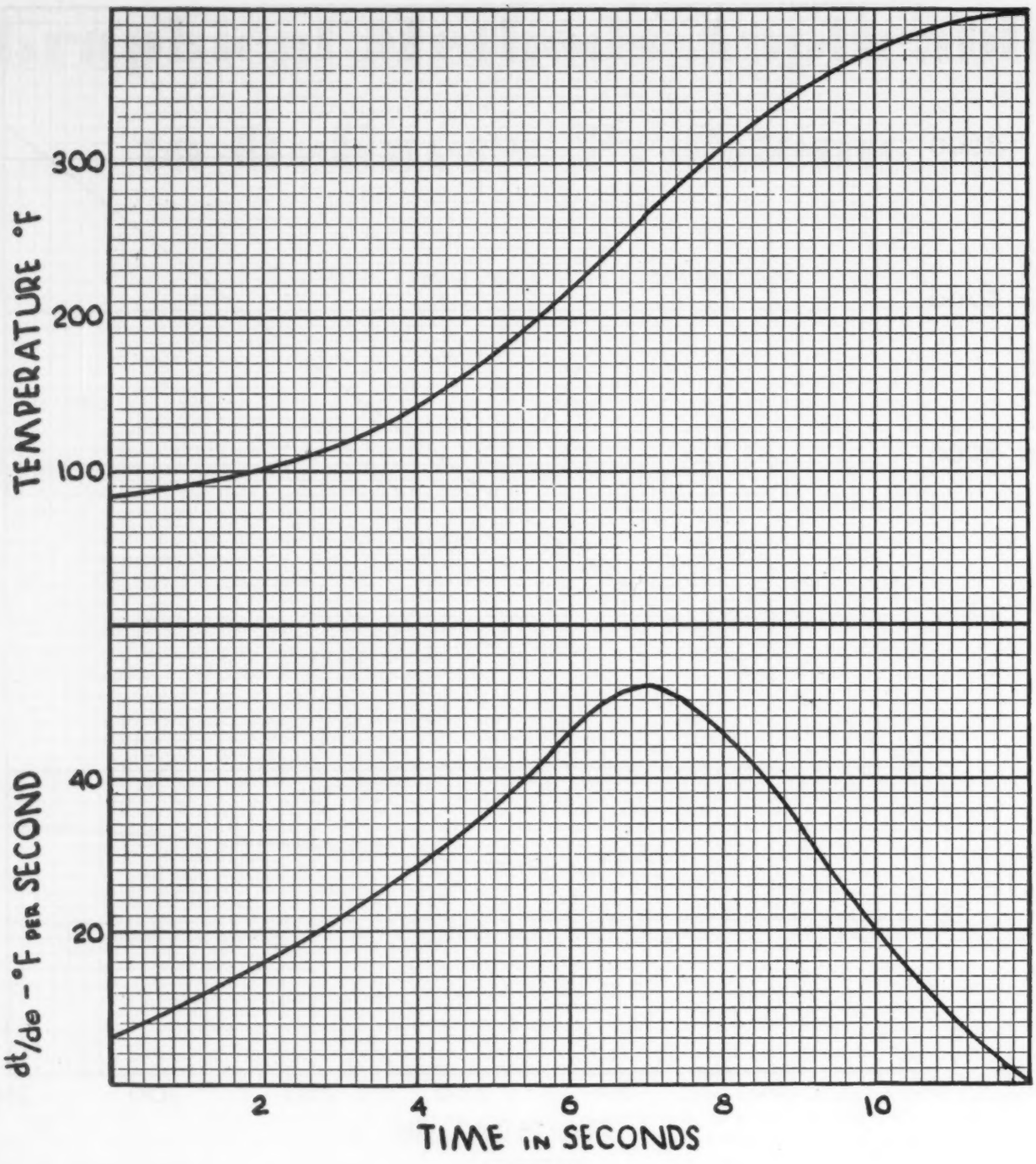

FIGURE 2

duce the original curve. Since the lower curve is derived from the first, any adjustment of the differential curve, which will make it more closely reproduce the integral curve, is an entirely legitimate correction. Thus the error in differentiation can be reduced to a negligible quantity by making a second approximation on the true location of differential curve. The differential curve in the above example was found to have a percentage error of 2.6 percent upon integration, using the trapezoidal method. An unknown fraction of this was due to the integration. An adjustment, of this curve, can be made so that at every point it will exactly reproduce, upon integration, the curve from which it was derived.

From this rate of change of temperature with respect to time, the rate of heat transfer can be calculated for any point in the system. Thus the distribution of the heat load can be readily checked. It is only necessary to know the heat capacity, mass velocity and cross sectional area of the equipment. The use of differential quantities, point conditions, is a great aid in attacking the problems presented by continuous flow systems, because instantaneous and not average values are employed.

The area under a curve, the integral of the function represented by the curve, can be determined in a number of ways. The simplest is to count the squares that are contained within the area considered. In most cases this requires rather tedious counting. The area may be

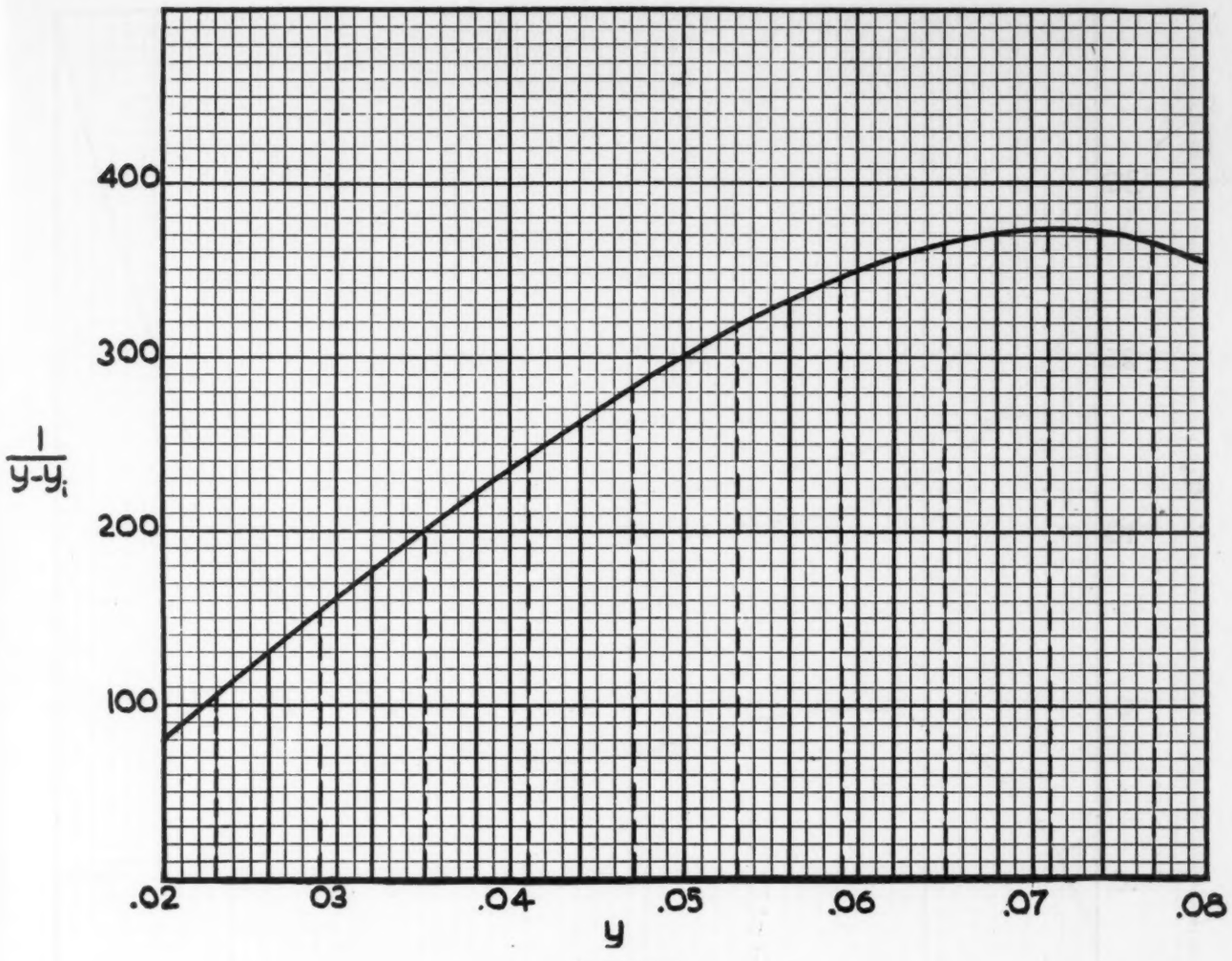

FIGURE 3

measured directly by means of a planimeter which are normally calibrated to give the area in square inches. The result must be converted to the proper units. This is accomplished by multiplying the area in square inches by a factor which depends upon the scales used in plotting the curve. The factor is the product of the number of units per inch on the Y-axis times the number of units per inch on the X-axis.

One of the best and easiest methods of graphical integration is provided by the application of the trapezoidal rule. This consists of determining the mean value for the ordinate by taking the arithmetic mean of a number of equally spaced ordinates across the interval being integrated and then multiplying this mean value by the difference in abscissa between the limits of the interval. It will be observed that as the number of ordinates measured increases without limit that the area will approach the true integral. The spacing is entirely a matter of judgment on the part of the calculator. Too small a spacing results in needless labor and too great a distance between measurements in unnecessary error. The basis of the method is the assumption that, if the spacing between ordinates is small enough, the curve will closely approximate a straight line across this space. Consideration of the radius of curvature is therefore the major factor in determining the width of the spaces.

By measuring the height of the ordinate at the midpoint of the spaces, a further refinement of the operation is obtained. If both of the extreme ordinates are measured, an error will be introduced because these extremes will be weighted twice relative to the others. If only one is included, it may not represent the average of the two. This error may be avoided by weighting the terminal ordinates one half or by measuring the ordinates at the midpoints of the spaces.

The curve plotted in Figure 3 has been integrated by three different methods. The integration is that required for the determination of the volume of an absorption tower.

$$\int_{y_2}^{y_1} \frac{dy}{y\text{-}yi} = \frac{\pi kg\, a\, V}{NG}$$

Where
V = Volume of absorption tower.
N = Ratio of molecular weights
Y = Pounds of soluble material per pound invert gas.
π = Total pressure
kg = Gas film coefficient
a = Area of contact surface per unit volume of tower.
G = Weight of inert gas flowing per unit time
Subi = Interface
1 = Entering
2 = Effluent

Counting the squares, gave an area of 16.17. A total of 1617 of the smallest squares were counted, with each square representing area of 0.010. By use of the trape-

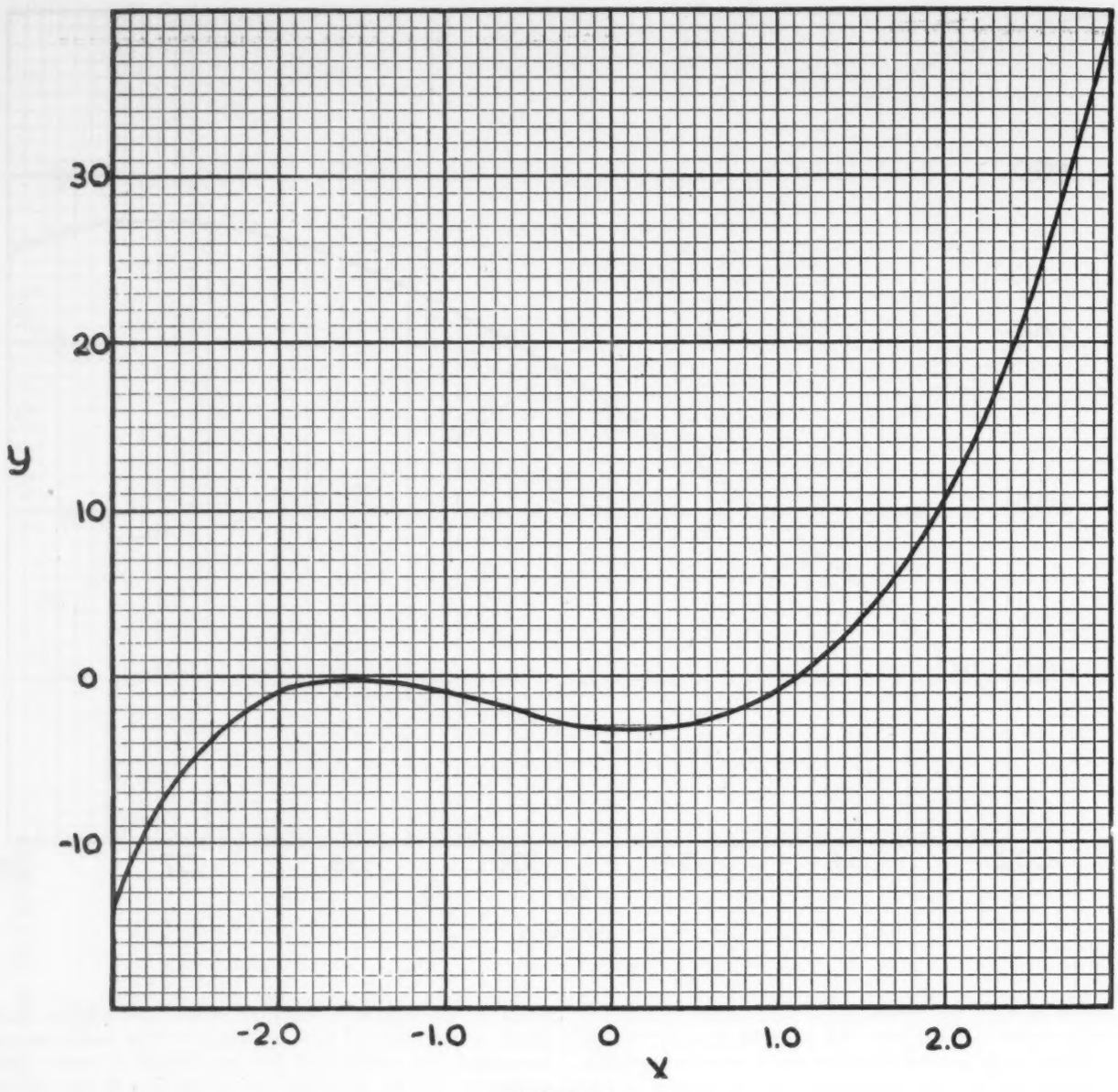

FIGURE 4

zoidal rule, measuring the ordinate at the midpoint of 10 equal spaces the integral was 16.45. This represents a difference of 1.9 percent. Reduction of the number of spaces to 5, gave a figure of 16.55 for the area. This amounts to a change of only 0.6 percent. It must be noted that the variation will differ for different curves.

Measurements with a planimeter gave an area of 16.37 expressed in the same units. Since the volume of the tower is directly proportional to the value of the integral, any of these methods will ordinarily give satisfactory results.

In refinery calculations, equations of higher degree are occasionally encountered. The roots of a quadratic can be readily obtained by the general method for second degree equations or by the use of the slide rule. Every quadratic equation may be reduced to the standard form:

$$X + aX + b = 0$$

Where a and b are constants which may be either positive or negative. Factoring $(X + r)(X + s) = 0$

Where the product $rs = b$
and the algebraic sum $r + s = a$

If the runner, on the slide rule, is set on b on the D scale then r will be read on C scale immediately above b and s will be read on the D scale under 1 on the C scale. Proper adjustment of the slide will give values of r and s which will satisfy the condition that their algebraic sum must equal a. These values, r and s, are the desired roots of the equation.

Although it is possible to solve the general cubic and quartic equations directly by algebraic methods, these solutions are somewhat involved. Equations of still higher degree cannot be solved algebraically. Expressions involving terms of any degree may be solved by graphical means with the accuracy of the solution being a direct function of the care used in plotting. The graphical solution will indicate all of the real roots of the equation if the functions are plotted between sufficiently wide limits.

Either of two methods may be used. The expression may be plotted directly or it may be plotted as two separate functions. The solution of the cubic will be

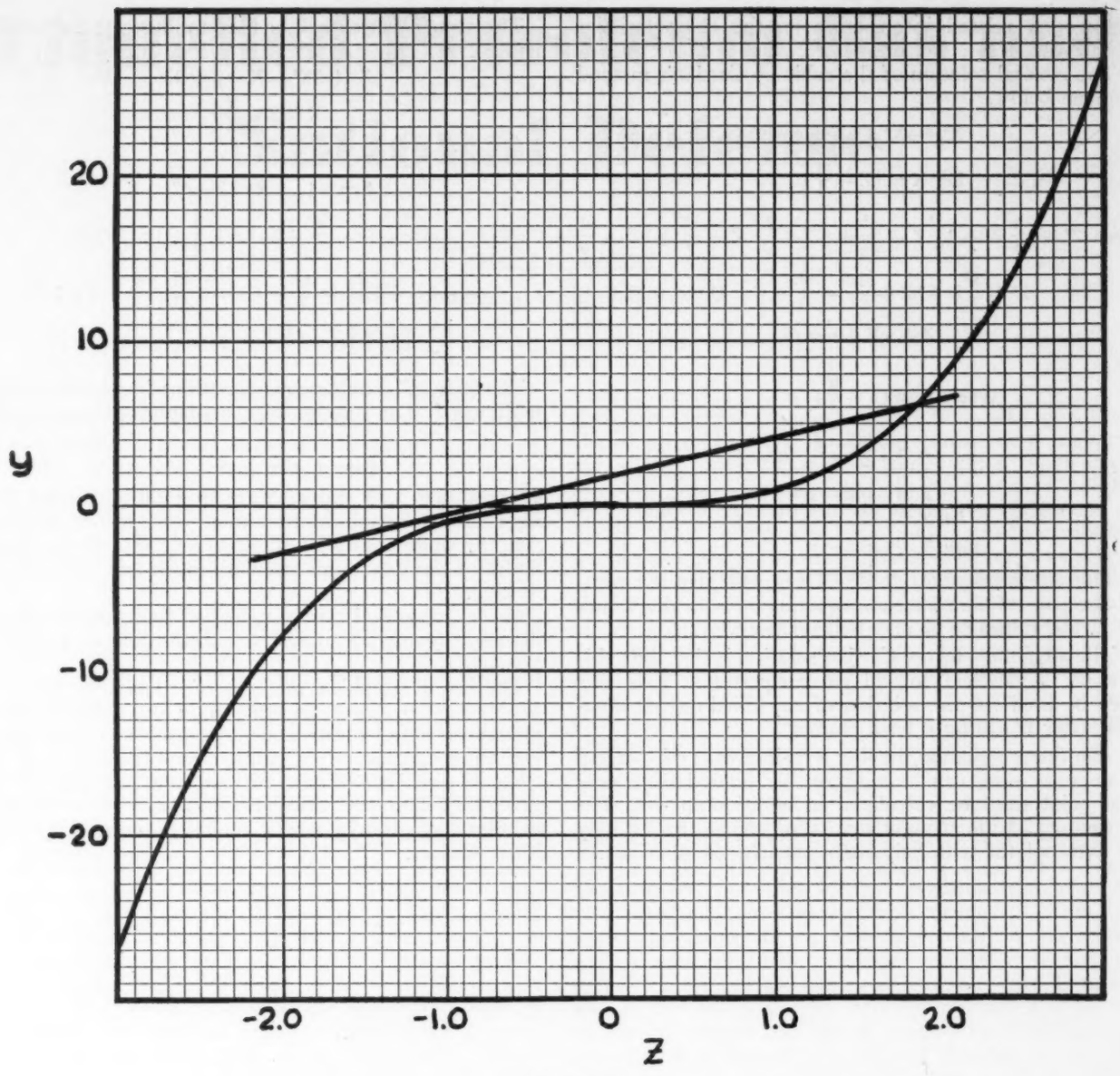

FIGURE 5

illustrated by the use of both methods. The following expression is used as an illustration.

$$X^3 + 2X^2 - X - 3 = O$$
$$f(X) = X^3 + 2X^2 - X - 3. = O$$
At $Y = f(X)$
When $Y = O$

The values of X will be the roots of the equation.

TABLE II
Corresponding Values of X and Y

X	Y	X	Y
3	39	—1	—1
2	11	—2	—1
1	—1	—3	—14
0	—3		

These values of X and Y are plotted in Figure 4, with the abscissa expanded 10 times in order to make the curve easier to read. To accurately plot a cubic, it is usually necessary to determine the location of the maximum and minimum through which the curve passes. The usual process of differentiating is followed as illustrated below.

$$d(X^3 + 2X^2 - X - 3) = 3X^2 + 4X - 1$$
When $3X^2 + 4X - 1 = O$

the curve passes through a minimum or maximum. The values of X and Y for the maximum and minimum are:

Minimum $X = 2.3, Y = -3.1$

Maximum $X = -1.5, Y = -0.38$

Since the maximum lies below the X axis, the curve only intersects the X-axis at one point. Therefore the only value of X which will satisfy the original equation is

$$X = 1.13$$

In this instance only by the determination of the maximum could this be shown to be true. Normal plotting would have indicated several additional solutions in the region of the maximum. In order to obtain the best results by graphical method, it is often necessary to

apply such related information on the characteristics of curves.

The general solution of the cubic by Cardan's method is given below.

$$X^3 + aX^2 + bX + c = O$$

$$\text{Let } X = (Z - \frac{a}{3})$$

$$\text{Then } Z^3 - 3\frac{a}{3}Z^2 + 3\frac{a^2}{9}Z - \frac{a^3}{27} + aZ^2 - \frac{2a^2}{3}Z + \frac{a^2}{9} + bZ - \frac{ab}{3} + C = O$$

$$Z^3 - \frac{a^2}{3}Z + bZ + \frac{2a^3}{27} - \frac{ab}{3} + C = O$$

$$Z + mZ + n = O$$

$$\text{Where } m = (b - \frac{a^2}{3})$$

$$n = (\frac{2a^3}{27} - \frac{ab}{3} + C)$$

$$Z = -mZ - n$$

$$\text{let } Y = -Z$$

$$\text{then } Y = -mZ - n$$

The intersections of these curves will give the roots of the pair of simultaneous equations. From the values of Z, the values of X may be calculated.

The advantage of the Cardan solution is that the cubic $Y = Z$ is identical for all cubic equations. This may then be used for the solution of any third-degree equation after it has once been plotted.

The linear equation, having a Y-intercept of —n and a slope of —m, can be very readily plotted since only one point need be calculated in addition to —n. The advantage of the straight line is, of course, that it may be extrapolated with only slight constructional errors.

The same equation will be used to illustrate the second method.

$$X^3 + 2X^2 - X - 3 = 0$$

$$X = Z - \frac{2}{3}$$

$$a = 2 \qquad c = -3$$

$$b = -1 \qquad X = Z - .67$$

$$-m = -(a - \frac{a^2}{3} + b) = +\frac{4}{3} + 1 = +2.33$$

$$-n = -(\frac{2a^3}{27} - \frac{ab}{3} + C) = \frac{-16}{27} - \frac{2}{3} + 3 = 1.74$$

$$Y = 2.33\,Z + 1.74$$

$$Y = Z^3$$

The pair of simultaneous equations has been plotted in Figure 5. The solution of the simultaneous equation,

$$Z = 1.82$$

gives a value of $X = 1.15$

These values 1.13 and 1.15 are in good agreement for the results a graphical treatment. The second method gave the single solution without recourse to the determination of the maximum and with much less difficulty in plotting.

Cardan's method can be extended to equations above the cubic by making successive substitutions of the same type.

The use of graphical methods of calculation, particularly the use of graphical integration and differentiation greatly simplifies the treatment of problems concerning continuous processes. If average conditions, instead of accurate point conditions, are employed, errors will be introduced into the calculations. Many problems can be solved graphically which cannot be attacked in any other manner.

Liquefied Petroleum Gas and National Defense

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THE war in Europe started as a war of nerves. It has settled down to a war of commonplace things, such as beans and beef and guns and gasoline. And of these things, gasoline and other liquid fuels probably will decide the outcome, since transport trucks, tanks, airplanes, submarines and even battleships become useless junk without a continuous supply of the proper kinds of fuel. A country can adjust its needs for food and clothing and shelter within wide limits, according to the necessities; but an aggressor cannot attack, nor can a defender resist, without a complete and generous supply of liquid fuels.

In view of the desperate condition of the democracies in Europe, and the obvious bearing of this condition on our own affairs, it is essential that the liquefied petroleum gas industry take a general look at its present position in the family of liquid fuels, with the purpose of determining how it can best serve in the national defense economy. It is the purpose of this paper to suggest some of the trends into which the development of the use of L.P.G. should be directed in order to yield the greatest benefit in our preparation for defense, as well as in our normal utilization of fuel.

First, let us examine into the general nature of the fuels classified as liquefied petroleum gas—or L.P.G.—to see how they differ from other liquid fuels, and in what way these differences affect their production, distribution and use.

Chemically, L.P.G. consists of one or more of three definite chemical compounds, known as propane, isobutane and normal butane. All three of these materials are heavy combustible vapors under ordinary conditions of temperature and pressure, but may be liquefied by compressing to a moderate pressure, and can be stored as liquids in tanks under pressure. The pressures required to keep the material liquid at normal atmospheric temperature, say 80° F., range from 130 pounds per square inch for pure propane down to 23 pounds per square inch for pure normal butane. The storage pressures for mixtures vary between these two extremes, depending upon the proportions of propane and butanes. Storage tanks often are subject to temperatures much higher than 80° F., consequently it is necessary to use tanks designed for at least 225 pounds per square inch working pressure for storing propane, and about 125 pounds for butane.

This, then, is the first unique peculiarity of L.P.G.; the storage tanks must be built for considerable pressure, and are therefore much more expensive than storage for ordinary liquid fuels like gasoline, Diesel oil or fuel oil. Likewise, tanks for transporting L.P.G. must be much heavier than those used for other liquid fuels, so that the ratio of tare weight to net fuel weight is higher. This last difference is partly offset by the fact that the liquefied petroleum gas weighs per gallon only about 70 percent as much as gasoline. Therefore, for those uses where a gallon of L.P.G. will deliver as much actual duty as a gallon of gasoline, the total or gross transport weight per unit of duty performed may be about equal to that of gasoline. Although transportation to a distance is not impractical, L.P.G. is essentially a fuel for home use at stationary points, and is not well adapted to military field operations.

Sources

The second fundamental difference between L.P.G. and other liquid fuels arises from its method of production. The principal sources of L.P.G. are natural gasoline plants, which extract gasoline from the natural gas produced along with crude oil from oil wells. In these plants the extraction of the light natural gasoline from the gas normally results in the extraction of an excess of propane and butanes which can be converted into commercial L.P.G. by extremely simple and cheap processing. The rate of production of nearly all natural gasoline plants is determined by the rate of production from the field; in other words the L.P.G. is in the nature of a by-product, the supply of which is determined largely by factors beyond the control of the L.P.G. industry itself. L.P.G. production conditions thus are similar to those of natural gas production from oil fields, in that the rate of supply is set by outside factors which bear no relation to the rate of demand, and the excess production is expensive to store away in quantity.

During the past few years the practice of storing excess natural gas production by pumping it back into the producing or other formations underground has grown rapidly, and this same method of storage may be applied to excess L.P.G. Subsequent use of the stored gas requires only that it be produced into transmission lines through existing wells, but recovery of L.P.G. stored in the same manner necessitates again running the gas through an extraction plant.

These, then are the two distinctive peculiarities of L.P.G. among liquid fuels; first, it is expensive to store in large quantities, and second, it originates principally as a by-product of the production of other fuels. In order for L.P.G. to have its greatest usefulness, these peculiarities require that its utiliza-

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tion be expanded to the greatest possible extent consistent with the available supply. Every gallon of L.P.G. which is wasted, or which is used for purposes where a less specialized fuel like natural gas or fuel oil or coal would do equally well, requires the production of an additional gallon of war purpose fuel to take its place.

Uses

We will now discuss the uses of L.P.G., in an attempt to evaluate those uses with reference to the national defense.

Utilization of L.P.G. falls naturally into three broad classifications according to the nature of the use, as follows:

1. Burning fuel.
2. Internal combustion engine fuel.
3. Raw material for chemical conversion.

Based on the figures for 1938 as assembled by the United States Department of Commerce, of total consumption of 165,201,000 gallons, 66 percent was used as burning fuel, 12.6 percent as engine fuel, 19.6 percent for conversion into other chemicals, and 1.8 percent for miscellaneous use not otherwise classified.

As will be shown, L.P.G. possesses remarkable properties as an engine fuel; yet the above figures indicate that about two thirds of the total amount sold is used for burning fuel, one fifth is used for chemical conversion into other materials, and only one eighth for engine fuel. The reasons for this state of affairs will appear in the following discussion of the development of the three types of use.

Use as Burning Fuel

The original application of L.P.G. was as a substitute for gas for domestic cooking and heating. Mixtures composed mostly of pure propane were distributed in small tanks or "bottles" of 5 to 20 gallons capacity. The installation of a pressure regulator and a small amount of piping to carry the low-pressure vapor to the stove, water heater, etc., completed a household gas service installation. Atmospheric temperature supplied enough heat to vaporize the liquid in the "bottle" as fast as needed. This extremely simple and cheap installation brought to any home all the advantages and convenience of natural gas. Of course, the high cost of the distribution in small quantities to scattered and often isolated customers resulted in a high price for the fuel, so that it never could compete where natural gas was available.

During the first years of the L.P.G. business, from 1922 to 1928, practically all sales were of the "bottle-gas" type. In this period the total sales grew from about 200,000 gallons per year to 2,600,000. In 1928 appear the first substantial sales for industrial use, amounting to 400,000 gallons for the year. This type of application was simply a logical expansion of the "bottle-gas" idea, extending the use of the fuel to all sorts of firing which require absolute cleanliness or exceptionally sensitive control, or both. The installations become more complicated, requiring artificial heat for vaporizing the liquid at the necessary rates of use.

The fuel is transported in rail tank cars or large tank trucks for transfer to stationary storage tanks at the point of use. Since 1928 the industrial use has grown from 400,000 gallons annually to 128,000,000 in 1939, while in the same period the bottle-gas business has increased from 2,600,000 to 84,600,000 gallons.

In general the industrial applications, like the domestic, simply offer a substitute for other forms of gas service. Where natural gas is available at usual rates, L.P.G. cannot compete in cost for equal amounts of heat. Thus, as a practical proposition, its industrial use is limited to applications where natural gas would be used normally if it were available. Such uses include:

Firing ovens in bakeries.
Baking drying enamels on sheet metal parts.
Burning vitreous enamels on stoves, plumbing fixtures, refrigerator parts, etc.
Melting glass and blowing glassware.
Firing high-grade pottery.
Singeing textiles.
Heating, treating and annealing tool steels, etc.
Dehydrating fruits, vegetables, alfalfa, cotton, etc.

All of these uses take advantage of the fact that L.P.G. fuel is clean and odorless, and contains no harmful materials, so that the products of combustion can come into direct contact with the material to be heated without injuring it in any way. In every case the delicate control of temperature is also important; such control is easy to secure with a gas fuel.

An interesting special use for L.P.G. is as a substitute for acetylene gas for cutting iron and steel. It has been found that L.P.G. and oxygen produce a cutting flame nearly as effective as that of the usual acetylene-oxygen mixture, at materially reduced total cost. Since production of machine parts by automatic torch cutting machines is growing rapidly, this use of L.P.G. may be expected to increase.

Still another unusual use of particular interest now is the firing of mercury smelters on several California mercury properties. In this case the cleanliness of the fuel avoids contamination of the mercury, and increases the net production of clean metal enough to more than compensate for the higher cost of the L.P.G. as compared with fuel oil. Needless to say, it is unlikely that this type of use will spread to the smelting of ordinary metals.

Standby Plants

The use of L.P.G. for emergency or standby fuel service has been developing extensively during the past three or four years. Such plants are of two general types; those intended purely for emergency service in the event of failure of the normal source of gas fuel, and those used to supplement the normal supply during periods of peak demand. Standby plants have been built of all sizes, from an emergency plant to supply a large city at the rate of 36,000,000 cubic feet per day, down to small industrial units designed to deliver a few hundred feet per hour.

Emergency standby plants to insure the operation of vital war material factories against temporary failure of their normal gas supply will afford an important element of protection in the national defense. Gas manufacturing or distributing centers are particularly vulnerable to damage by sabotage or aerial bombing. The installation of L.P.G. standby plants at the vital points of use will distribute this risk, making it impossible for a single act of destruction to shut down more than the one unit which is directly affected. Such standby units can be made

quite secure against attack, since the storage tanks can be buried, or better, installed in concrete vaults; and the compact vaporizing equipment can be similarly protected.

Recently another application for standby plants, that of supplying a factory with gas during peak gas load periods, has begun to develop. Most natural gas systems allow substantial reduction in industrial gas rates if the customer will accept service which may be cut off on notice during heavy load periods.

By installing an L.P.G. standby unit which is adequate to carry over such periods, the factory owner can take advantage of the minimum rates for his normal gas service without having to interrupt his operation. In most cases such a standby plant will show handsome earnings on the investment through the savings in the normal gas rates.

A logical development from the bottle-gas method of providing individual domestic gas service was the installation of town systems to serve a number of customers. In such systems the L.P.G. is vaporized at a central plant, and the resulting vapor is distributed to customers at low pressures through pipes. In most cases the vapor is mixed with air or inert gas in order to produce a fuel which behaves more like natural gas than does the straight undiluted vapor. Such mixing is required in the colder parts of the country in order to prevent condensation in the lines, but in the warmer localities, unmixed vapor is used successfully.

The 1935 issue of the Handbook of Butane-Propane Gases lists 134 town plants in the United States and Canada, having a total population of 625,000 according to the 1930 census. Of these plants over 70 percent are of the vapor-air mixture type.

The same listing shows 21 construction camp plants on various power and water projects in California. This is an interesting special application of the town plant idea, bringing the advantages of natural gas service to isolated locations for cooking, water heating and space heating, thus adding much to the comfort and satisfaction of the men. In several cases these camps were located 300 to 400 miles from fuel sources, and six of them were in the high mountains at altitudes around 8000 feet.

The town-plant idea is obviously applicable to permanent or semi-permanent military establishments, such as isolated coast defense batteries and air service fields. The one fuel can be used to supply heat for cooking, water heating, space heating and even lighting. It can also be used to fuel electric generating sets, water pumping units, and other powers as required.

Still another modification of the town-plant idea is the use of L.P.G. at artificial gas plants to enrich or sweeten the artificial gas. The usual types of artificial oil-gas plants operate most efficiently when making gas of low heating value. The heating value of such gas can be improved by mixing L.P.G. vapor with it, thus realizing most economical operation of the gas plant and at the same time producing an excellent grade of gas.

Internal Combustion Engine Fuel

Use as internal combustion engine fuel permits liquefied petroleum gas to display its unique valuable properties to the utmost. Several of its applications to burning service are extremely valuable, but in practically every case other liquid fuels could be substituted at some additional inconvenience and expense. As applied to internal combustion engines, and particularly to automotive machines, L.P.G. possesses several absolutely distinctive advantages over all other liquid fuels.

These advantages arise from three peculiarities of the fuel as applied to engines:

First, since it is prevaporized and fed to the cylinders as an absolutely dry mixture of vapor and air, no lubricating oil dilution can occur.

Second, for the same reason, the charge burns cleanly and completely.

Third, the fuel shows an effective octane number of 100 to 115, which gives remarkably smooth operation and reduces structural strains in the engine parts.

We will discuss these points in some detail, to see what they mean in the practical operation of engines.

Shortly after making the first serious conversions of heavy equipment in 1933, many operators began to notice that their engines ran much longer between overhauls than they had when fueled with gasoline. In several cases of extremely heavy equipment running at maximum load almost continuously, the service period between repair jobs was more than doubled.

For instance, one of the earliest operators to convert heavy trucks to L.P.G. found that the interval between engine overhauls was increased from about 50,000 miles to over 115,000, and that after this increased period of service the engines were in better shape generally than they had been after the shorter period running on gasoline. Based on the accumulated experience gained from many thousands of conversions during the past seven years, it is conservative to say that the service period between overhauls is increased by 50 percent, or in other words, the repair expense is reduced by one third. There are definite records of many conversions where the improvement has been much greater.

Although all three of the special qualities of L.P.G. engine fuel undoubtedly contribute to this result, it seems clear that the most direct reason for the improvement in engine life lies in the absence of crankcase oil dilution. All ordinary gasolines contain materials which boil at temperatures of 400° F. or over. These high-boiling heavy ends are seldom if ever actually vaporized in the charge entering a cylinder, but rather are in the form of a fine spray suspended in the air. This spray has the natural tendency to deposit on the comparatively cool cylinder wall, where it mixes with and dilutes the film of lubricating oil on the wall. During the next stroke the diluted oil film is swept off and down into the crankcase; thus the entire charge of oil is gradually diluted and contaminated with the non-lubricating heavy ends of the gasoline, destroying the lubricating quality of the oil.

With L.P.G. fuel the effect of operation on the lubricating oil is exactly the opposite of this. The heaviest material in L.P.G., normal butane, boils at 33° F., consequently the carburetion equipment has no difficulty in vaporizing the charge into an absolutely dry mixture. As a result, the lubricating oil never shows any trace of dilution, but actually increases its viscosity slowly due to the distillation of the lighter parts of the oil out of the cylinder film. Operators are accustomed to compensating for this effect by using a lighter grade of oil for make-up.

The absence of oil dilution permits the oil to main-

tain its original lubricating qualities, and thus affords the engine maximum protection from wear. As a corollary, the useful life of the oil itself is extended. Operators who change oil according to physical tests, and not because they think it has run long enough, find that intervals between changes can be tripled or better, and still the average condition of the oil will be much better than with gasoline fuel.

Clean burning of the fuel charge helps promote long engine life indirectly, since the products of combustion consist only of water vapor and carbon dioxide, with only a trace of monoxide if the carburetor is properly adjusted. Thus there are no intermediate partially-burned and cracked products to form gummy carbon deposits on rings and valves. One other minor advantage of L.P.G. in this connection lies in the fact that the commercial grades are almost or totally free from sulphur compounds, whereas sulphur is present in appreciable amounts in practically all motor gasolines. On burning, the sulphur forms oxides which combine with water to form actively corrosive acids.

One of the results of clean burning is the absence of disagreeable odor in the exhaust gases. This advantage is of real importance in connection with passenger busses, particularly in congested traffic where more or less exhaust gas works into the passenger compartment in spite of all precautions. Not only is the exhaust gas free from offensive smell, but carbon monoxide is practically absent, so that there is much less chance that the exhaust will affect sensitive passengers.

In one of the first passenger bus experiments a single bus was converted to L.P.G. out of a large fleet. After a few weeks the operator noticed that this particular bus, which was on short interurban service, turned in more fares than any of the other outwardly identical busses on the same run. The operating company received several letters from habitual riders on the line, asking what had been done to that bus to eliminate fumes, and why the rest of the busses could not be fixed up the same way.

The high octane number of L.P.G. fuel makes for smooth, flexible operation, and eliminates excessive explosion pressure strains in the engine. It is felt that this factor contributes appreciably to the reduction of engine maintenance costs. This property permits lugging grades a gear or two higher than is customary with gasoline fuel, resulting in substantial savings in running time.

Conversions of ordinary gasoline automotive equipment to use L. P. G. fuel are simple and cheap. A pressure fuel tank and special vaporizer and carburetor unit are all that is necessary, although it is usually advisable to increase the engine compression ratio in order to realize maximum economy. Combination carburetor units are available for normal operation on L. P. G., which permit running on gasoline in emergencies.

In spite of the fact that a gallon of average L. P. G. mixture represents only about 80 percent as much actual fuel value as a gallon of average gasoline, under usual conditions the L. P. G. will deliver gallon for gallon about the same duty when used as automotive fuel. The greater thermal efficiency of the L. P. G. is due primarily to the clean and complete burning and to the high octane rating which permits the use of higher compression ratios. Incidentally this improved efficiency causes the engine to run cooler under a given load; consequently in the average case a given engine will deliver more power with an equal degree of heating. In many instances careful tests have shown an increase of available power output of about 20 percent over that obtainable from the same engine when fueled with gasoline.

To sum up; the use of L. P. G. as domestic automotive fuel, releasing equivalent volumes of gasoline for direct war use, represents perhaps its most effective outlet in the national defense, for the following reasons:

It speeds up the operation of equipment.

It reduces material and labor required for maintenance.

It sharply decreases lubricating oil consumption.

Some figures on the present state of the application of L. P. G. to internal combustion engines are interesting.

Data just released by the Bureau of Mines shows that during 1939 total L. P. G. sales in California amounted to 48,497,000 gallons, of which 24,048,000 gallons, or practically 50 percent, was used for engine fuel. Thus while the country-wide average is only 12.6 percent it is nearly four times as much here. The reason for this seems to be simply that the development of automotive use happened to get started on the Coast, perhaps due to the fact that we use heavy truck transportation more here than elsewhere. Interest in this type of application is beginning to grow in other parts of the country, so that a rapid development is expected during the next few years.

Estimates based on data from carburetor manufacturers and others indicate that there are at least 15,000 applications of L. P. G. fuel to internal combustion engines. Of this number, certainly not less than 80 percent, and possibly 90 percent, are on automotive equipment. Data on current sales of equipment indicate a present rate of probably 400 conversions a month.

Experience with L. P. G. as automotive fuel on a practical scale goes back to about the middle of 1933. An infinity of details of carburetor equipment, fuel tank design, fittings, pumping, metering and dispensing systems had to be worked out before the applications could be called commercially successful. Along with this development, it was necessary to cooperate with the safety and fire prevention regulatory bodies, so as to establish reasonable standards of safe practice. By 1935 most of the details of physical equipment had been worked out, and a safety code was established by the National Fire Protective Association and the California Industrial Accident Commission which has had a thorough testing by experience since then. The record of safety for this type of use shows that both the equipment and the regulations are adequate for all practical requirements.

Internal combustion engine use of L. P. G. includes every imaginable type of application. Automotive use includes, in the approximate order of the numbers of the applications, farm tractors, trucks, harvesting and other special agricultural machinery, special dirt moving equipment, road building machinery, semi-portable oil and water well drilling equipment, and even a small number of private automobiles.

Among the earliest automotive applications were

several rail motor coaches of the Southern Pacific. Railroad use was extended last year to include a streamliner on the Union Pacific in Kansas, as well as the conversion of several rail motor coaches. In these applications the greatly increased power output from the engines was a real factor in increasing payload and making possible improved schedules.

Stationary engine use includes well pumping for irrigation, electric generator units, air compressors, mine hoists and in fact about everything which is operated by a gas or gasoline engine.

The use of L.P.G. for wearing-in engines after assembly, is becoming increasingly popular. It has several obvious advantages for this work, such as cleanliness, ease of connecting up and disconnecting, and elimination to a large extent of fire hazard around the testing stand. One peculiar advantage lies in the fact that the fuel is free from sulphur or any other material which might leave a corrosive residue on the engine parts; hence it is not necessary to go to elaborate lengths to clean out the engine after the run-in. This point has particular value in connection with wearing-in airplane motors.

As Raw Material for Chemical Conversion

Polymerization—It was discovered about eight years ago that butanes, and even propane to some extent, could be partly converted into heavier fuels in the gasoline range by subjecting them to the proper amount of heat and pressure. In the process, a large proportion, ranging from 40 percent to 65 percent, of the original L. P. G. charged into the plant is degraded into fixed gases. At the time these processes were developed, the L. P. G. charge stock was looked on as a waste product, hence any use which conserved part of it was beneficial provided the operation would pay. However, if the mixed propane-butane charge stock has a value even as low as about 2 cents per gallon for use as L. P. G., most polymerization operations would not pay.

The polymerized gasoline produced by these processes has a high effective octane number for blending; consequently war requirements might change this economic picture somewhat. Nevertheless, the conversion of propane itself is so inefficient in any present polymerization process that it would not be used for charge stock if it had any value at all for direct fuel use.

As far as we know, only one polymerization unit has ever been built to operate exclusively on iso- and normal butane derived from a natural gasoline plant. At last reports, this plant was processing about 1200 barrels per day of pure butanes unmixed with propane. The plant is in a location where probably it would be impossible to develop a direct market for such a large amount of butane, hence the charge stock has little or no alternative value. Our information regarding this operation indicates that it is only moderately profitable.

On the basis of present knowledge it seems unlikely that the practice of polymerizing butane will expand greatly. It seems probable that such operations of this type as are not in existence would be converted to other types of cracking if the L. P. G. charge stock should, through increased direct use, develop a market value bearing some reasonable relation to its intrinsic merit.

Alkylation—Recently several schemes have been developed whereby iso-butane can be converted by a comparatively simple and inexpensive process into iso-octane. This material has an octane number of 100, and has great value as an ingredient of fighting-grade aviation gasoline. Subject to the limitations imposed by the cost of fractionating the iso-butane and gathering it from its scattered sources into a central alkylation plant of reasonable size, this use of iso-butane would probably take precedence over all others in the national defense fuel economy.

However, such diversion of iso-butane will have no serious effect on the development of the direct use of L. P. G. for a long time, since it is estimated that iso-butane constitutes not more than 20 percent of the volume of present commercial L. P. G. materials. As will be shown, the present total utilization consumes about 20 percent of the readily available supply of L. P. G. materials, so that the diverted iso-butane can be replaced easily.

Synthetic Rubber—Within the past few months have been announced by the Goodrich Tire and Rubber Company and Standard Oil Company of New Jersey, two different processes for the manufacture of synthetic rubber from petroleum as a raw material. The immediate product which serves as the starting point for the synthesis is a hydrocarbon called butadiene, a sort of first cousin to butane. Butadiene can be made by cracking crude oil or distillates; it can also be made by removing some hydrogen from butane.

As far as we can determine from the published material, the production of the butadiene by cracking is probably cheaper than making it from butane, particularly if the butane has a reasonable value for direct use. At present it is impossible to judge how far this development may affect the utilization of butane for fuel purposes. But even if all the available butane were absorbed for the manufacture of rubber, the same operations required for the extraction of the butane will yield large amounts of propane. Nothing that has been said in this whole discussion about the uses of L. P. G. is limited to either propane or butane or any particular mixture of them, and there is plenty of room for further expansion of L. P. G. utilization even if all the butane were used for other purposes.

Undeveloped Supply

An attempt has been made to estimate the economically available supply of L. P. G. Starting with the statement in a recent A. P. I. report on natural gas that the total wet gas processed by natural gasoline plants is currently 5,600,000,000 cubic feet per day, we then have to estimate the average available L. P. G. (propane and butanes) content of this gas in excess of the butane absorbed by the natural gasoline production. We have estimated that this excess content averages 1 gallon per thousand cubic feet, and that the average gasoline plant can capture half this amount with a reasonable outlay for L. P. G. equipment.

On this basis, the readily available supply is 2,800,000 gallons per day, or just over a billion gallons a year. This is nearly 5 percent of last year's total consumption of gasoline in the United States; it is also over six times last year's consumption of aviation gasoline.

The best present estimate of total L.P.G. consumption for 1939 is 227,000,000 gallons; thus the industry has plenty of room to grow, and still take care of all existing fields of use.

Annealing Furnace Permits Re-Use of Still Tubes

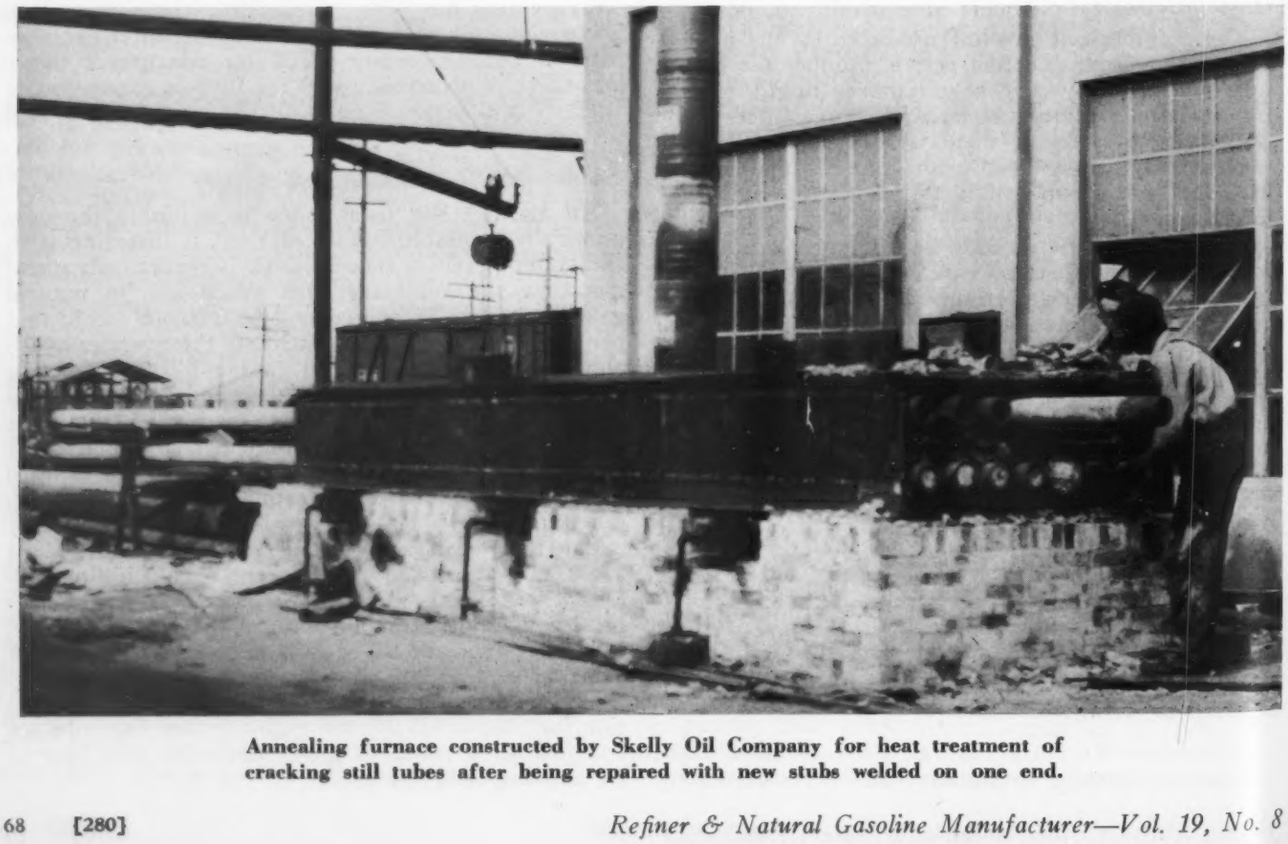
By developing a heat-treating furnace to anneal cracking still tubes, Skelly Oil Company has been successful in reconditioning such equipment in its refinery at El Dorado, Kansas, by welding ends on the tubes to replace that part damaged by corrosion and erosion. The tubes are calipered and thoroughly inspected upon removal from a furnace during reconditioning shutdowns, and those with thin walls throughout most of the length are discarded.

Tubes which have been damaged only at the header roll are cut back an average distance of 2 feet, which covers virtually all of the damaged metal. When making the cut, the tubes are set in a lathe in the machine shop and the cut is made in the form of a U bevel. Ends for welding to the tubes being repaired are cut from tubes which would not be of sufficient length after the damaged part had been removed. These are cut in 2-foot sections, one end being square, and the other with the U bevel for welding.

The tubes, after being cut to standard length by removing the 2 feet of damaged end, are swung from the lathe by a swinging crane and chain hoist to be stacked conveniently for the welders, with the U bevel end farthest from the shop. Each tube in turn is placed on a welding rack, one at each end, and supported in the center by the chain hoist. The rack at the squared end of the tube is similar to a carpenter's saw horse, made of angle iron, and having a section of 2-inch angle iron tacked to the top with the channel up to make a double knife-edge bearing point for the tubes to rest upon. The welding end support is similar to the back one, but has a much more narrow face, and has an angle iron fastened to it with the channel up, and placed lengthwise of the tube for a rolling bearing for tube and stub which is being welded to the tube.

With the principal portion of the tube weight resting upon the chain hoist, the tube may be rolled as the weld is made. The welding of the stub to the tube is done with an electric torch, and the rods are low chrome with ½ percent molybdenum. The weld is made by running the bead in the U bevel, requiring that the tube be turned three times, as it requires three layers of metal to completely fill the U bevel and bring the joint flush with the outer surface of the tubes. After the tubes are re-lengthened, they are stacked in the stock pile waiting to be heat treated in the annealing oven.

The annealing oven is made with a fire-brick com-



Annealing furnace constructed by Skelly Oil Company for heat treatment of cracking still tubes after being repaired with new stubs welded on one end.

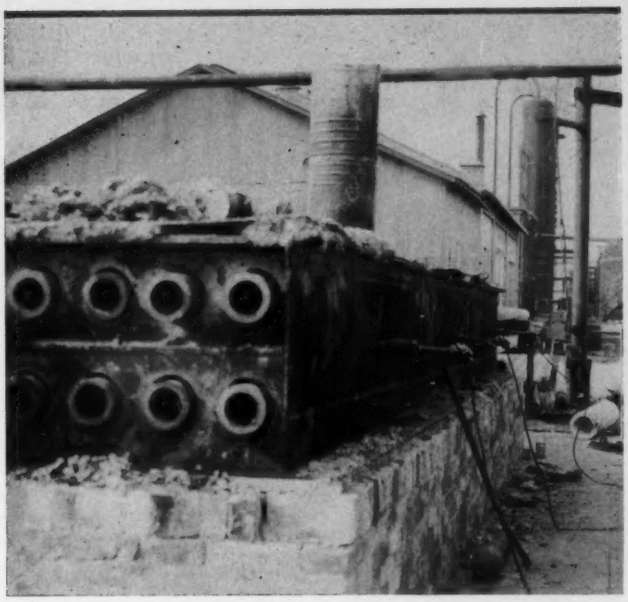
bustion chamber 8 bricks high, laid flat, and another layer on top of this with the bricks laid edge-wise. It is 6 feet wide and 15 feet long. Three burners are inserted near the top, on one side, having gate valves for the control of fuel. The super-structure, that contains the tubes, is made of steel sheets, each end being perforated with 16 holes to contain 16 tubes at one heat. Tube supports are placed at intervals, set between each burner, to carry the weight of the tubes and to prevent them from becoming malformed when the heat is brought to the highest point in the oven. These tube supports are similar to those in cracking stills and protected on either side with refractories. The cover for the oven is also made of steel, in three sections. The center section is laid upon the others, so it may be moved without disturbing the remainder of the oven when filling or removing the tubes. A stack to vent combustion gases is attached to the center of this section, and is about 10 feet high.

End of tube showing bevel cut when damaged end is removed for welding new stub.

On the side of the oven opposite the burner controls are three thermocouples connected to a recording instrument so the progress of annealing may be watched and controlled. The thermocouples are inserted in the metallic substructure directly opposite the burner controls so that the highest heat applied to the tubes can be recorded. The recording instrument, with a roll chart, is hung on the outer wall of the machine shop, 6 feet from the oven.

After the oven has been filled with the tubes for treating, all openings in the super-structure are closed with plastic insulation, similar to that applied to boilers by mixing with water and troweling on. The stub end of the tubes is placed flush with the end of the oven, and the holes closed with insulating plastic so that air will not circulate through them while being treated. The long end of the tubes, hanging out from the other end of the oven is covered with split magnesia insulation so there will be no abrupt change in tube temperature from the inside of the oven to the outside.

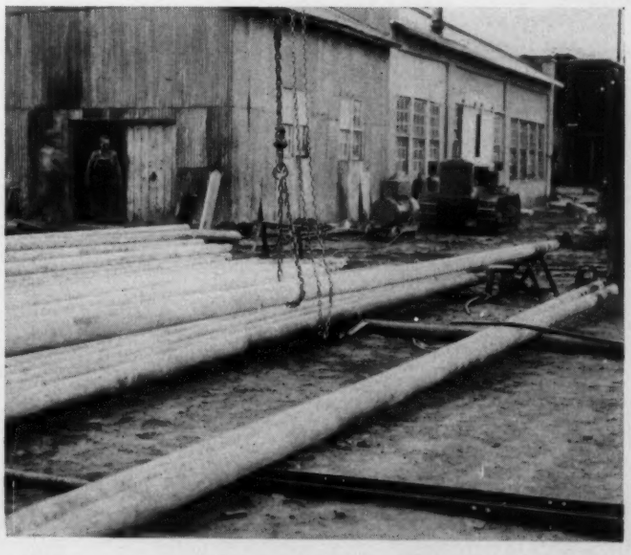
After the tubes have been placed in the oven, and all openings plugged, the fires are lighted and the temperature brought up gradually throughout the



Thermocouples at three points control temperature

length of the oven. Temperatures are raised to the same degree in all three combustion spaces so that treatment of the tubes is uniform for about two thirds their length. The temperature to which the annealing is carried depends upon the type alloy from which the tubes were originally formed and is maintained after reaching that point for several hours. When the time has elapsed which is necessary to relieve all stresses, the heat is lowered and finally cut off so that the tubes can be placed in the cracking, or processing furnaces and be operated with safety.

To handle such long tubes with large diameter, a tractor crane is used to lift each in turn, held so they will pass through the openings in the oven. The same is true of removing them. The crane is lowered almost to the level of the tube so that a chain looped around the end extending from the oven and connected to the hoisting cable can be used to pull, rather than lift the tube.



Recondition tubes on welding rack

A New Firing Time Test

JACK DE MENT

OFTEN an investigator enters the realm of a new subject in science only to find that he has a task which seems insurmountable, not because it is intricate but because it is enormous. Such is the case of a new and unique method for testing liquid inflammables and, in a way, analyzing unknown materials. It is possible only to outline the test itself and to suggest technique, apparatus, and uses to which it may be applied.

It was noted in the laboratory that many organic inflammable liquids, when ignited, burned with a time characteristic for each sample. It was also noted that when a standard procedure was followed the flames, deposits, residues, colors, types and heats of flames were also characteristic for each sample deflagrated. This simple principle provided the foundation for a new method for testing materials. The test is especially applicable to liquids; somewhat applicable to solids; and there are indications that gases may also be tested by this method by using improved apparatus and technique.

Apparatus and Procedure

The apparatus and procedure are simple. The measured sample is poured into a standardized porcelain or metal watch glass. This vessel is termed a firing vat. Assuming that the liquid is inflammable at ordinary temperatures it is ignited and the time is taken for the sample to burn. The time required for this sample to burn completely, under ordinary (or otherwise specified) conditions, is termed the Firing Time Period—FT.

Experimental: One milliliter of the liquid flammable sample was piped into a porcelain watch glass 7.0 cm. in diameter and 1.1 cm. high having a concave bottom. The liquid was introduced gently from above so as to prevent undue surfacing or washing of the vessel. The liquid was ignited with a match and the time required for complete combustion was noted with a stopwatch. The vat was at room temperature and was free from convection currents. Results by this technique for liquids are shown in Table 1.

TABLE 1

FT/1 ml. $_{20\ deg.\ C.}$—Liquid Inflammables

SAMPLE	Seconds
1. "White" gasoline; as obtained	95.0
2. Same; after 12.0 hours exposure to the air	90.2
3. Same; after 24.0 hours exposure to the air	70.0
4. Gasoline sample "A"	66.1
5. Gasoline sample "B"	84.2
6. Gasoline sample "C"	72.0
7. Gasoline sample "D"	88.9
8. Gasoline sample "E"	74.3
9. Gasoline sample "F"	69.1
10. Dimethylketone, comm., sample X	86.0
11. Dimethylketone, comm., sample XX	82.1
12. "Absolute" methanol; sample "A"	45.0
13. "Absolute" methanol; sample "B"	39.1
14. "Absolute" methanol; sample "C"	44.3
15. Ethanol, comm., 95 percent	59.6
16. Isopropanol, comm., 70 percent	55.2
17. Ethyl ether, c. p.	41.4
18. Benzene, comm.	77.1
19. Nitrobenzene	51.4
20. Paraldehyde	98.9
21. Xylol, comm.	76.4

It might be noted that the Firing Time Period, FT/1 ml.$_{20\ deg.C.}$, includes that period which is inclusive of the first appearance of the flame on ignition to the last appearance of the same flame upon being extinguished.

The notation, FT/1 ml.$_{20\ deg.C.}$, is used to denote the conditions and relations involved in the test. It is evident that the notation used in the first table includes FT which denotes Firing Time; 1 ml. which indicates the amount of liquid used; and a subscript 20 deg. C. which states the temperature at which the test was conducted—in this case meaning room temperature. It is obvious that values are of the c.g.s. type (seconds for the *final*), likewise the notations:

1. FT/R ml.$_{t\ deg.C.}$ = indicate general relationships.
2. FT/1 ml.$_{20\ deg.C.}$ = indicate the most convenient form of the test—that conducted at room temperature.
3. FT/R ml.$_{0\ deg.C.}$ = specify that the test be conducted at 0° C.
4. FT/1 ml.$_{40\ deg.C.}$ = ...
5. FT/5 ml.$_{20\ deg.C.}$ = ...
6. FT/10 ml.$_{20\ deg.C.}$ = ...
7. FT/R ml.$_{m.p.}$ = specify that the test be conducted on the sample when it is at its melting point.
8. FT/R ml.$_{b.p.}$ = same but for boiling point.
9. FT/R ml.$_{100\ deg.C.}$ = specify that the sample be tested at 100°C.
10. FT/R ml.$_{t\ deg.C.}$(O_2) = indicates that the sample is to be fired in an atmosphere of 100% O_2.

For exceedingly volatile liquids an extremely rapid technique must be acquired to insure accurate results. In any case, exposure to the air, in some samples, and frequent handling of the sample or the use of soiled or warm vats will reduce accuracy or otherwise render the results undependable. To illustrate this, the values in Table 1 might be noted. Extremely accurate values may be obtained with apparatus compensating for vat surfacing, humidity by dessication, pressure, deflagration variance by the use of a pure oxygen atmosphere (see notation 10, above), and convection currents by special containers, together with any other factors which will enter into combustion.

As has been stated, this test is apparently characteristic for individual samples of materials. Its variability is very small in the sense that values obtained upon the same sample, under the same conditions,

TABLE 2

Methanol (absolute), rapid technique

Test Number	Ft./1 ml. 20°C. =Seconds
1.	45.0
2.	46.9
3.	41.6
4.	44.5
5.	47.2
6.	45.1
7.	44.9
8.	45.0
9.	44.8
10.	45.0
11.	44.9
12.	45.1
13.	45.0
14.	45.9
15.	45.8
16.	44.1
17.	45.1
18.	44.8
19.	45.1
20.	45.0
Average	45.0

with the same apparatus, correspond very closely. It is probable that any large variations in FT for a sample of repeated determinations are due to discrepancies in the measuring process, or otherwise. In Table 2 are values obtained for a sample of methanol by repeated testing and then cooling the vat to room temperature after firing and using again.

The previous explanation of the test has been for liquids only and liquids that burn at ordinary temperatures. To modify this test for those materials which do not burn easily, either solid or liquid, the following technique was used:

In a suitable flammable solvent the sample of liquid or solid was dissolved. The test was then performed in the same manner as that in which a homogenous liquid was used. Values for such determinations are given in Table 3.

It is obvious that greater accuracy wil be obtained with larger samples, therefore, quantities less than 1 ml. should not be used for significant determinations (see notations 5 and 6, above). Also, the operator must keep in mind that there is no simple relationship between time, FT, and the quantity of the sample consumed or introduced, i.e., FT is not half for half the sample.

Outlined are factors characteristic of this test. These may be modified to suit the specific use to which the test is to be applied:

TABLE 3

Inflammable Mixtures

SAMPLE	Ft./1 ml. 20°C. =Seconds
1. FT 45 methanol with 0.05 ml. dimethylketone	48.1
2. FT 82 dimethylketone with 0.05 ml. non-inflammable liquid	74.2
3. FT 95 gasoline with 0.05 ml. mineral oil	50.3
4. FT 86 dimethylketone with 0.20 gm. sucrose-sample I	75.4
5. FT 86 dimethylketone with 0.20 gm. sucrose-sample II	80.1
6. Oleum turbinthae: methanol (1:3)	67.0
7. Oleum turbinthae: methanol (1:1)	80.1
8. Oleum turbinthae: methanol (3:1)	73.8
9. Oleum turbinthae: methanol (x:y)	78.4
10. Dimethylketone: methanol (1:9)	40.0
11. Dimethylketone: methanol (2:8)	92.1
12. Dimethylketone: methanol (3:7)	84.7
13. Dimethylketone: methanol (4:6)	88.0
14. Dimethylketone: methanol (1:1)	97.2
15. Methanol: water (9:1)	45.3
16. Methanol: water (8:2)	45.0
17. Methanol: water (7:3)	55.1
18. Methanol: water (6:4)	35.0
19. Methanol: water (1:1)	46.4
20. Methanol: water (4:6)	37.1
21. Methanol: water (3:7)	21.5
22. Methanol: water (2:8)	Will not Fire
23. Methanol: water (1:9)	Will not Fire

(Water is left in the vat in the methanol: water tests.)

Scheme of FT Determinations

1. Time; the fundamental quantity is the time-value obtained by noting the time required for a measured amount of a substance to burn. Time values are apparently characteristic for individual samples.

2. Flame; significant data pertinent to the flame of the deflagrating sample are:

A—Qualitative.
- 1. Color of the flame.
  - a—homogenous dispersion of the color.
  - b—variance of colors—several present.
    - 1. characteristic distribution.
    - 2. non-characteristic distribution.
  - d—luminous.
  - e—non-luminous.
  - f—factors relative to depth and intensity, etc.
- 2. Tip of the flame.
  - a—smoky or carbonaceous.
  - b—hot, complete combustion.
  - c—luminous.
  - d—non-luminous.
  - e—morphology.
    - 1. sharp apex.
    - 2. irregular tip.
    - 3. undulated.
- 3. Above the flame.
  - a—clean combustion.
  - b—smoke (re III).
- 4. Below the flame.
  - a—sample boils during deflagration.
  - b—sample does not boil during deflagration.
  - c—thermochromatic changes in the sample.
    - 1. during deflagration.
    - 2. after deflagration.
  - d—thermomorphological changes in the sample.
    - 1. during deflagration.
    - 2. after deflagration.

B—Quantitative.
- 1. Height of the flame.
  - a—measured in cm. from tip to base or to the surface of the liquid.
    - 1. distance between the surface of the sample and the base of the flame.
    - 2. no distance, flame burns directly on the surface.
  - b—flame decreases characteristically (graphed).
- 2. Temperature.
  - a—estimated by comparison with standards.
  - b—determined exactly with a gallium thermometer or a mercury thermometer.

3. Smoke; data pertinent to the material which comes from and superposes the flame.

A—Qualitative.
- a—color.
- b—type.
- c—form on emission.
- d—maximal distance above the flame tip at which it may be seen.

B—quantitative.
- a—gravimetric determination of the deposit.
- b—microscopic examination and measurement of particle size.
- c—patterns formed when deposited.

4. Residue; the portion, either solid or liquid which remains after combustion has ceased.

A—Type—Solid or Liquid.
- a—as estimated by comparison with standards.
- b—description of the morphology and type of this residue.

B—Amount.
- a—determined gravimetrically.
- b—measured volumetrically.
- c—measured in terms of pH.
- d—described.

C—Miscellany.
- a—color.
- b—transparency.
- c—homogeneity.

1. suspended particles and their analysis.

d—pH.
e—viscosity.
f—refractive index.
g—surface tension if a liquid.
h—specific volume.
i—specific gravity or density.
j—crystalline structure.
k—further special chemical determinations.
l—further special physical determinations.
m—residue spatters during deflagration.
1. distance the particles are thrown.
2. pattern formed by these particles.
3. application of the data in this scheme to the particles.

In all of the properties notated in this scheme it is possible to prepare standards by the discriminate use of purified and predetermined flammable liquids such as: hydrocarbons, alcohols, ethers, oils, aromatic compounds, ketones and aldehydes.

Applications

In the case of the test itself and the values and properties obtained with it I can present but a rough list of the variance in application in relation to the petroleum industries in general. It is apparent that the scope and applicability of this test are quite large, therefore, as a result of this, the following small list is given for the satisfaction of those interested in the versatility and many possible applications:

1. General application to laboratory operations requiring individualization of samples.
2. Standardization of base chemicals used in the various processes of the gasoline and petroleum industries.
3. Investigations into liquid fuels.
4. Establishing prerequisites for gasoline relative to uses in engines for special purposes.
5. Batch testing of oil samples.
6. Grading fractions as they are obtained from the towers.
7. Classifying crudes and residues.
8. Investigations into the smokiness of fuels.
9. Solvent refineries and paint work.
10. Waxes, asphaltum, tars, roofing and protective materials.
11. Flue gas testing.
12. Resins and similar materials.

This list is by no means complete, however, it may be of value if it suggests uses and applications or stimulates investigation.

Modifications

Other than tests upon the materials as they are obtained there are several methods for modification and preparation which are suggested for substances which will not otherwise respond to simplified FT procedure.

With solids there are several methods of treatment which have been used with success. Possibly the most used was the previously discussed resolvency of a solid sample in a suitable solvent of desired flammability. By fusion of the material and obtaining FT while molten values may also be obtained; this is applicable to resins and heavy tars and hydrocarbons. Constant m.p., or b.p., may be maintained with an electric hot plate. Metathetic modifications are necessary in many cases before the sample will respond to FT procedure.

Often it is necessary to add *activators* so that combustion will proceed at a greater rate. The activators act as either solvents or solutes relative to the sample. The corresponding use of *attenuators* is often indicated in the suppression of the somewhat troublesome hyperactive deflagration. The values given in Table 3 will demonstrate the action of these materials, even in small amounts, upon the FT value. Both of these materials must be thoroughly tested and purified before use. The specific type of material as used for its action in either case will depend on the individual application.

As has been stated, this test depends essentially upon the combustability of a material and from this FT is derived as the time required for an inflammable sample (or sample properly prepared) to burn or deflagrate under standardized conditions. It is obvious that FT may be extended and applied to many fields. Its simplicity in many cases makes it accessible to the lay operator. It may be performed with rapidity, the time required for one test being dependent on the apparatus, operator, sample and its preparation, time to fire, and the number and types of results which are to be observed, as well as their interpretation.

However, in summarizing I wish to point out that I have not attempted to cover the subject matter of the FT test minutely but instead I have endeavored to present its fundamentals and indicate their possible value for many processes of the petroleum industry. Moreover, it is obvious that some phases of the test have been treated and presented rather subjectively, but in spite of this the basic idea appears to be significant since this test may serve to introduce fundamental principles heretofore overlooked.

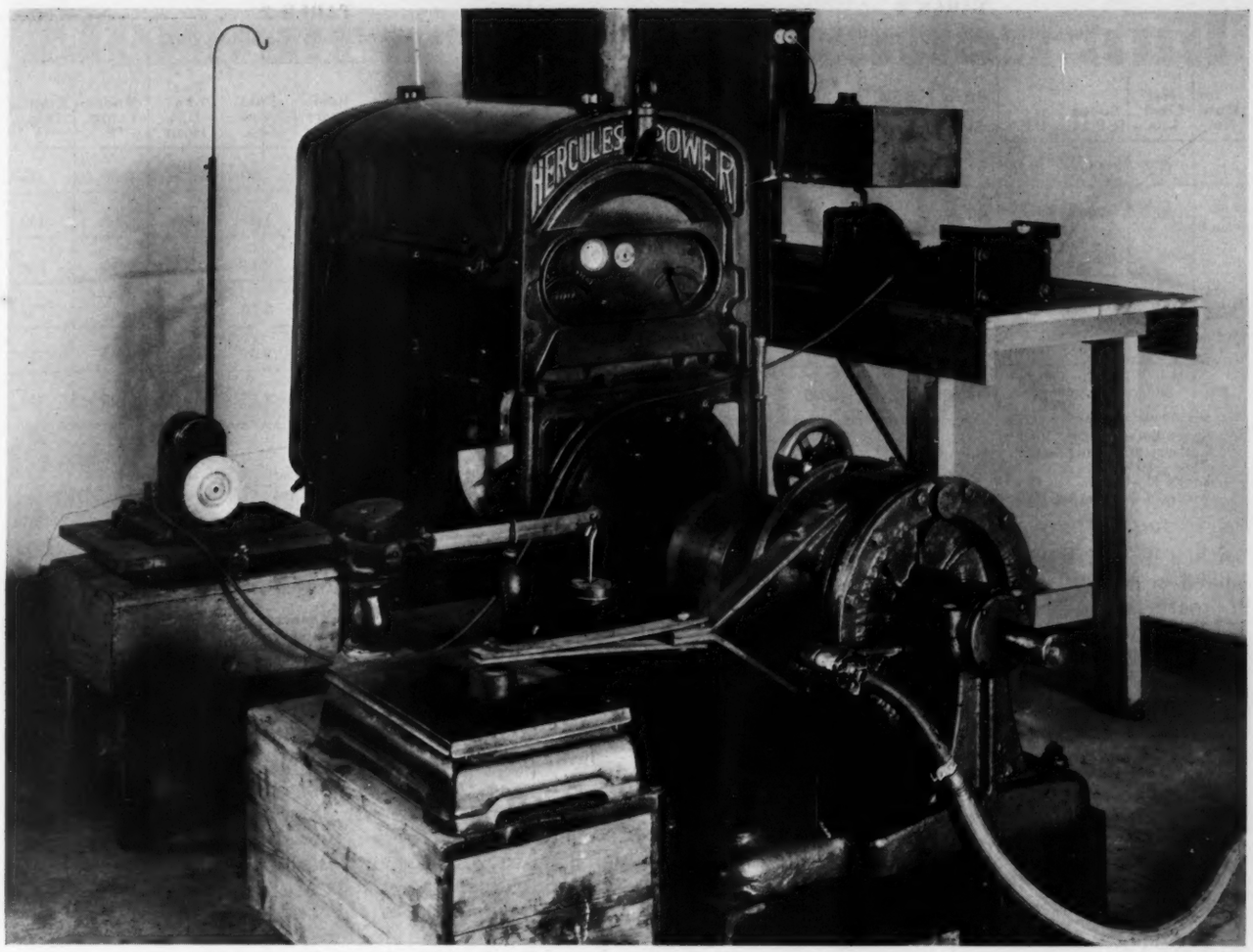


FIGURE 1
Engine and dynometer used in fuel tests

The Behavior of Gasoline-Coal Fuel in Spark-Ignition Engines

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FROM time to time it has been suggested that mixtures of petroleum and pulverized coal be used in internal combustion engines. This subject has received more attention in Europe because of the scarcity of motor fuels, but the suggestion has been brought forth in this country too as a step in petroleum conservation. Reports of the experimental work done are sketchy and cover a limited number of tests. Recently it has been demonstrated that this "liquid coal" can be used in an automobile[1] but details and results of this test are lacking.

The purpose of this paper is to present data on actual engine performance where a gasoline-coal suspension was used as fuel and to compare the results obtained with those using gasoline alone. The gasoline used was a water-white commercial product having a specific gravity of 0.7234 at 60° F. (64.1 A.P.I.). A portion of this was set aside to be mixed with the pulverized coal. The gasoline-coal mixture had a specific gravity of 0.7332 at 60° F. (61.5 A.P.I.). This fuel contained 2 percent by weight of coal of a particle size ranging from 1 to 74 microns. The original plan was to use low percentages of coal at first and then increase the amount of coal in subsequent runs. This idea was abandoned after results of the first three tests were known.

The engine used for these tests was a 4-cylinder

[1] Ind. Eng. Chem. (News Edition) 17, No. 14, 478 (July 20, 1939).

TABLE 1
Variable Load—White Gasoline

Run No.	Net Load, Lbs.	Speed R.P.M.	HP.	Fuel: Start Stop	Fuel Used, Lbs.	Fuel Lbs., HP. Hour	Room Temp. °F.	Engine Temp. °F.
1	11.5	1194.2	5.50	32.90 **31.54**	1.36	1.485	63	126
2	20.	1200.5	9.61	31.54 **29.83**	1.71	1.070	56	134
3	30.	1206.1	14.48	29.83 **27.73**	2.10	0.872	58	144
4	40.	1204.5	19.30	27.73 **25.15**	2.58	0.803	58	156
5	50.	1199.0	23.99	25.15 **22.14**	3.01	0.754	58	165
6	58.	1203.0	27.96	22.14 **18.30**	3.84	0.825	58	172

Spark Setting—34°.
Carburetor Setting—185°.
Time—10 minute runs.
Brake K—0.0004.
Engine Compression Ratio—3.73 to 1.

TABLE 2
Variable Load—Gasoline-Coal

Run No.	Net Load, Lbs.	Speed R.P.M.	HP.	Fuel: Start Stop	Fuel Used. Lbs.	Fuel Lbs., HP. Hour	Room Temp. °F.	Engine Temp. °F.
1	12.	1200.4	5.76	33.13 **31.83**	1.30	1.354	59	136
2	20.	1203.7	9.64	31.83 **30.18**	1.65	1.028	60	140
3	30.	1201.0	14.41	30.18 **28.08**	2.10	0.875	60	148
4	40.	1203.3	19.29	28.08 **25.53**	2.55	0.793	62	158
5	50.	1202.9	24.10	25.53 **22.49**	3.01	0.752	62	171
6	54.5	1194.9	26.20	22.49 **18.76**	3.73	0.855	62	171

Spark Setting—34°.
Carburetor Setting—185°.
Time—10 minute runs.
Brake K—0.0004.
Engine Compression Ratio—3.73 to 1.
(Prominent Detonation on No. 6.)

with a 4-inch bore and a 4½-inch stroke. Its rated speed was 1200 rpm. This engine with the dynamometer and other accessory equipment is illustrated in Figure 1. The motor had been torn down and cleaned just before these tests. The first test was a variable load test on gasoline. This was followed by a similar test with the gasoline-coal mixture and then by a constant load test with this mixture. After these three studies the engine was again torn down for observation and cleaning. The operating data are given in tables 1, 2, and 3.

TABLE 3
Constant Load—Gasoline-Coal

Speed, R.P.M.	1199.4
Net Load	40 lbs.
Total Running Time	2 hrs. 5 min.
Fuel Used	31.60 lbs.
Engine Temperature	162° F.
Horsepower	1199.4 × 40 × 0.0004 = 19.19
Fuel, lbs./hp-hr	31.60 ÷ 2 5/60 ÷ 19.19 = 0.791
Engine Settings	Same as above

FIGURE 2
Condition of valves after tests. Left, exhaust valve, cylinder 3; center, inlet valve, cylinder 3; right, inlet valve, cylinder 4.

There was no appreciable detonation even at maximum load, when gasoline alone was used as fuel. When the gasoline-coal mixture was burned, however, the detonation at maximum load was very prominent. The engine developed less power when the mixture was burned, probably due to this detonation. In the constant-load test, the engine ran smoothly for a while, then started knocking after about 1¼ hours. From then on, it would detonate severely for a time, then free itself and run smoothly for a while before it started knocking again. The speed and hence the power decreased as the run progressed. At the end, the throttle was wide open in order to keep rated speed.

Since these tests covered only a short period, it was not possible to tell whether the coal ash adhered to the cylinder walls or went out the exhaust. So far as could be observed, the exhaust was perfectly clean. There was no smoke at any time.

Coke was deposited in loose flakes in the entire surface of the engine head. This deposit had an average thickness of 0.52 mm. and on analysis showed 82.0 percent fixed carbon, 16.65 percent ash, and 1.35 percent volatile. The nearer the fuel approached the combustion chamber the more coke formed. The manifold ports were filled with tar and the intake valves were thickly coated (see Figure 2). The coal apparently warmed enough to become plastic but did not become hot enough to burn completely.

Since a spark-ignition engine operates with less than theoretical air, conditions were favorable for coking. All the exhaust valves and ports were clean.

The lubricating oil was in extremely bad condition. A large quantity of tar which collected on the valve stems apparently worked its way down through the valve guides into the crankcase. This tarry material was found in the bottom of the crankcase when the engine was drained. There was no doubt as to the origin of this material since the crankcase had been removed, drained, and cleaned before the tests.

It should be emphasized that these results apply only to a spark-ignition engine. Similar oil-coal mixtures might work satisfactorily in Diesels. Plans for such tests are now under way.

Acknowledgment

This work was done in the Department of Chemical Engineering under Project No. 146 of the Kansas State College Engineering Experiment Station.

Elements of Vaporization and Condensation

PART VII
Distillation and Fractionation

R. L. HUNTINGTON, University of Oklahoma

ONE of the most important unit operations which the refiner and natural gasoline manufacturer performs is that of separating mixtures of hydrocarbons having different vapor pressures into narrow boiling products.

Early in the life of the petroleum industry this operation was called distillation. It consisted of the simple batch process of charging a shell still (Figure 1) about two thirds full of crude oil, and then gradually increasing the temperature of the contents at atmospheric pressure until the lighter fractions such as gasoline, kerosene and gas oil were vaporized and condensed in an overhead coil. As larger demands were made on refineries for increased output of petroleum products, efforts were directed toward development of continuous operations, and as a result the crude-oil charge was flowed at a steady rate through several shell stills in series (Figure 2), the temperature becoming higher as the crude stream progressed through the battery. By elevating the first gasoline topping still above the second one in the battery and so on down the line to the fuel oil or residuum still, the transfer of crude oil was effected without the use of pumps between the successive stills. This improvement in distillation practice was a big one over the previous batch method through the increase of capacity, however such operations today would be considered obsolete and too wasteful of heat. Much rerunning had to be done with the old shell still operation until the industry became cognizant of the need for fractionation. The shell stills then were equipped with uninsulated packed towers (filled with such materials as rock, steel shavings, etc.) which formed some reflux through the loss of heat to the atmosphere. Rapidly changing weather conditions would cause variable reflux rates and no small amount of difficulty in controlling the desired product.

Today the pipe still (Figure 3) has taken the place of the shell with a few exceptions such as where a volatile solvent or diluent may have to be

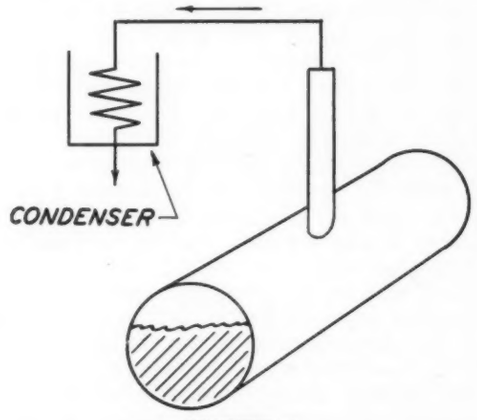

FIGURE 1
Batch still, first used for crude oil distillation

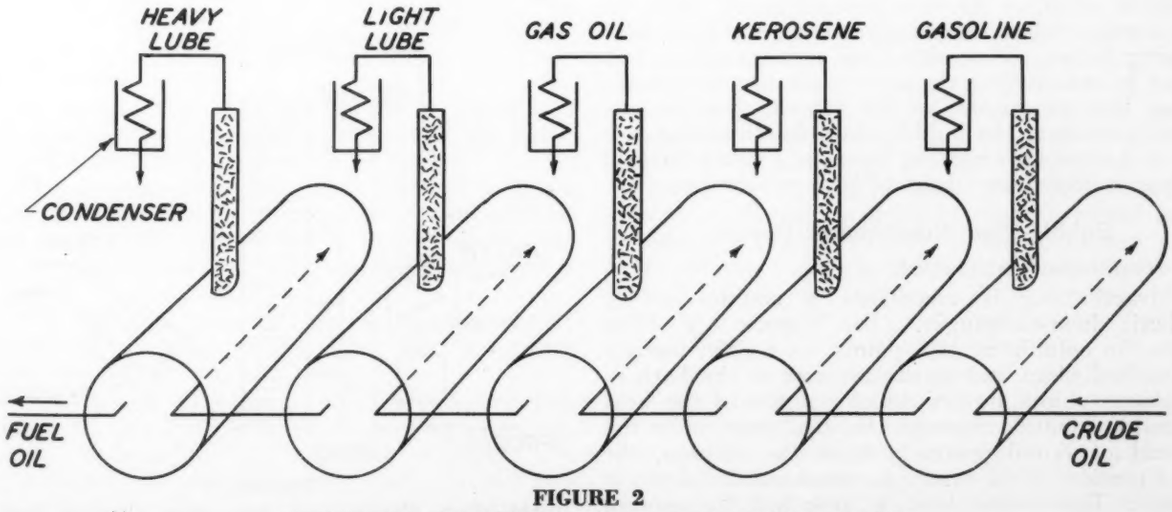

FIGURE 2
Continuous shell still battery, in common use 1910 to 1925

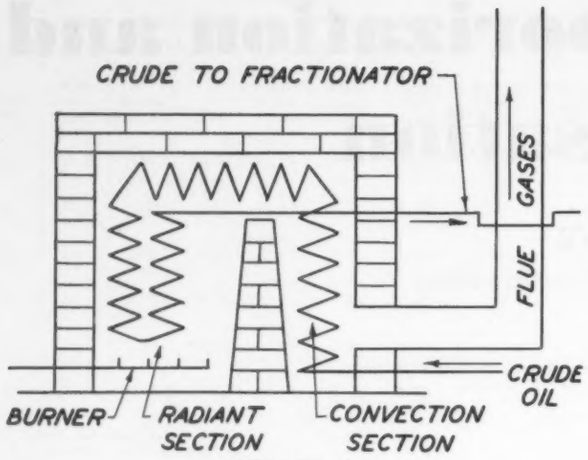

FIGURE 3
Conventional Pipe Still, in common use from 1925 to date

recovered from a non-volatile residue or extract. The pipe still offers several distinct advantages over the shell still.

1. Increase in heat transfer efficiencies.
2. Prevention of localized overheating and coking (frequent occurrence in shell still bottoms).
3. Less danger of excessive loss of crude oil in case of fire.
4. Closer approach toward flash vaporization in the pipe still.

Development of Fractionation

The packed tower which had been super-imposed upon the shell still, was transferred to the discharge of the pipe still. It was increased in height and instead of rock and steel shavings, further improvement in fractionation was accomplished through the use of various types of Raschig rings and spiral helices which provided greater surface areas for the contact of liquid and vapor. The industry was becoming aware of the fact, in the early twenties, that other industries had advanced the art of fractionation to a much higher degree than the oil companies. The manufacturers of alcohol had gone a long way toward the perfecting of bubble plate towers for fractionation of binary and multi-component mixtures.

About this time the natural gasoline industry was forced to stabilize its raw production in order to meet certain motor-fuel requirements, and to reduce shipping losses. The price these manufacturers had to pay by weathering the raw production to specification, was exorbitant so the natural gasoline engineer welcomed the bubble plate fractionating column as a means of reducing losses to a small fraction of those suffered by straight-batch weathering.

Bubble-Plate Fractionator Design

1. *Heat Input and Output*

A fractionator is essentially a counter-current adiabatic heat-exchanger. (See Figure 4.) Heat enters the column at two points, as a rule, namely at the feed plate and in the reboiler at the base of the tower. Since a very small fraction of the heat is lost by radiation through the insulation or by the removal of liquid products from the column, the major portion of the heat goes overhead in the vapor stream. This latent heat is absorbed by cooling water through the condensation of this vapor into liquid. A part of this liquid is in turn refluxed or pumped back into the top of the column to provide the liquid-vapor contact which is essential for the attainment of fractionation. Were no liquid condensed from the overhead vapor, the small amount of internal reflux which would form in the column would be equivalent only to the heat lost by radiation and convection through the insulated walls. Some of the early designers called for no insulation of the tower so that more reflux might be formed as the result of atmospheric cooling, but, as mentioned before in the case of the rock-packed tower, the close control of such a column under adverse or changing weather conditions was out of the question.

2. *The Bubble-plate and Downspout*

The efficiency of a fractionating column depends largely upon the intimacy of contact between the descending liquid reflux and the ascending stream of vapor. The packed column provided the necessary degree of efficiency so long as the packing remained intact. There was too often a tendency for this packing to shift and thereby permit the vapor to pass upward along one side of the tower without coming into well-distributed contact with the descending liquid.

The bubble plate can be depended upon to give uniformly good results from year to year unless corrosion causes appreciable reduction in the cross sectional area of the slots in the caps. The perforated plate (no bubble caps) has proven to be quite efficient for fixed liquid and gas loads. Below this specific load, the intimacy of contact is not adequate while excessive gas or reflux loads will prevent the downflow of liquid and the resultant priming or flooding of the tower.

A typical bubble cap plate is shown in Figures 5a and 5b, with the vertical and horizontal projections. The word "typical" might be contested, however, as the number of cap styles is legion, varying in shape such as square, round, or oblong not to mention the slots which may be rectangular, triangular or tangential. Several cardinal points are to be observed in general, in connection with the design of a bubble cap plate.

1. The velocity through the slots of the cap must be adequate to assure the formation of countless numbers of minute bubbles, but not so high as to blow the liquid away from the cap.
2. The overall pressure drop through the chimney,

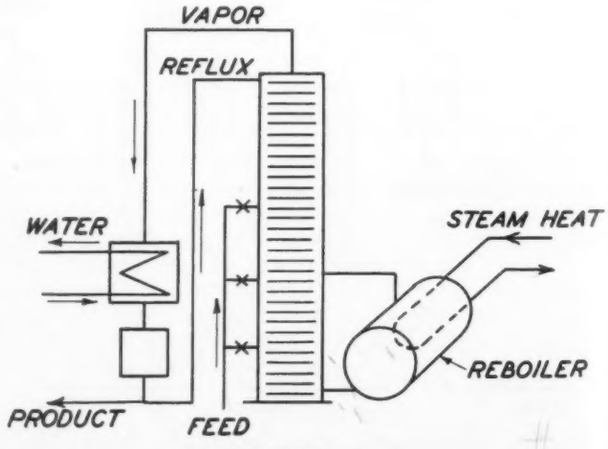

FIGURE 4
Bubble Plate Fractionator, heat input through feed and reboiler, heat output through overhead vapor.

bubble cap slots, and liquid on the tray must be less than the hydrostatic head of fluid in the downspout, otherwise vapor will flow up the downspout.[1,6]

3. The caps should be so arranged that there is no tendency for liquid to channel across the plate.

4. The caps should be a sufficient distance apart

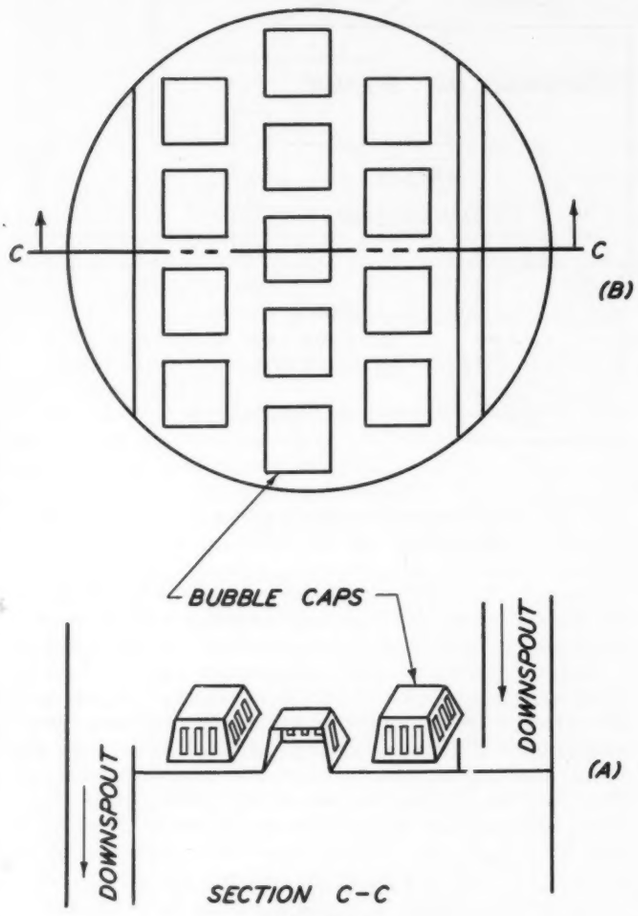

FIGURE 5
Conventional Bubble Cap Plate

to prevent interference with each other in the bubbling action of the vapor.

5. The overflow weir of the downspout should be higher than the top of the slots in the bubble caps, this differential height depending upon the permissible pressure drop through the liquid and froth above the plate.

6. If the diameter of a tower is large enough to cause a pronounced liquid gradient across the plate, more than one downspout should be used.

7. The downspout size is governed largely by the nature of the froth and its tendency to disengage its vapor load.[4,7] The trend has been toward the use of larger downspouts by blocking off a segment of the tower.

8. The distance between plates depends mostly upon the mass velocity of the vapor flowing upward through the tower.[2,3,5]

In 1923, when the natural gasoline industry first took up the practice of fractionation by removing the propane from the raw gasoline relatively low temperatures and pressures were used. Satisfactory results were obtained but the cost of refrigerating the overhead reflux proved to be excessive. The refrigeration system usually consisted of a butane or propane cycle (Fig. 6) in which a number of compressors were required for the transfer of heat from the overhead condenser to the water cooling tower. The low-temperature tower did have the advantage in that fewer bubble plates were needed in order to effect a certain amount of fractionation than a high-pressure high-temperature column would require. In a later paper of this series, the theoretical reasons for this reduction in the necessary number of trays will be explained.

By 1930, the low-temperature stabilizer columns had been practically supplanted by higher temperatures through the use of water as a condensation medium instead of propane or butane. By making this change, the capacity of the columns was increased due to the higher operating pressures. For example the throughput of the tower could be raised by approximately 40 percent by increasing the pressure from 50 up to 100 pounds per square inch absolute. This value was obtained by substitution in the entrainment equation:[6]

$$W = C\,[d_2\,(d_1 - d_2)]^{1/2}$$

where W = mass velocity of vapor in lbs./hr./sq. ft. of tower cross section.
C = a constant, dependent upon the tray spacing, physical properties of the fluids, etc.
d_2 = density of vapor in consistent units.
d_1 = density of liquid, in consistent units.

Except for extremely high pressures, the equation can be simplified to:

$$W = C\,(d_2\,d_1)^{1/2}$$

The big saving through high-temperature fractionation came through the use of water as a cooling medium to condense the overhead product, thereby making the use of compressors unnecessary in order to accomplish refrigeration.

The exacting specifications which the natural gasoline industry must meet in the manufacture of close-cut fractions has eliminated the use of the side-stripper. As a general rule, it requires at least (N — 1) towers to make (N) products. For example it would take two towers to separate a three-component mixture such as:

	Mol %
Propane	30
N Butane	30
N Pentane	40

into its respective components. This result can be accomplished by two different procedures as indicated by Figures 7a and 7b. The second one of these two methods is the more economical to operate as the heat requirements as well as the vapor load would be considerably greater for column 1 (7a) with the production of both propane and normal butane as overhead products than it would be for column 1 (7b). Furthermore, the overhead reflux from column 1 (7a) would have to be preheated before charging into column 2 (7a) whereas the hot bottoms from column 1 (7b) could be flowed directly into column 2 (7b) without preheating.

Another distinct advantage of installation (7b) over (7a) is the reduction in pumping costs, since a booster pump would be required to transfer the overhead liquid reflux from column 1 (7a) to column 2 (7a). If the overhead vapor from column 1 (7a) is condensed at 100° F. the pressure on the tower would be substantially the same as the vapor pres-

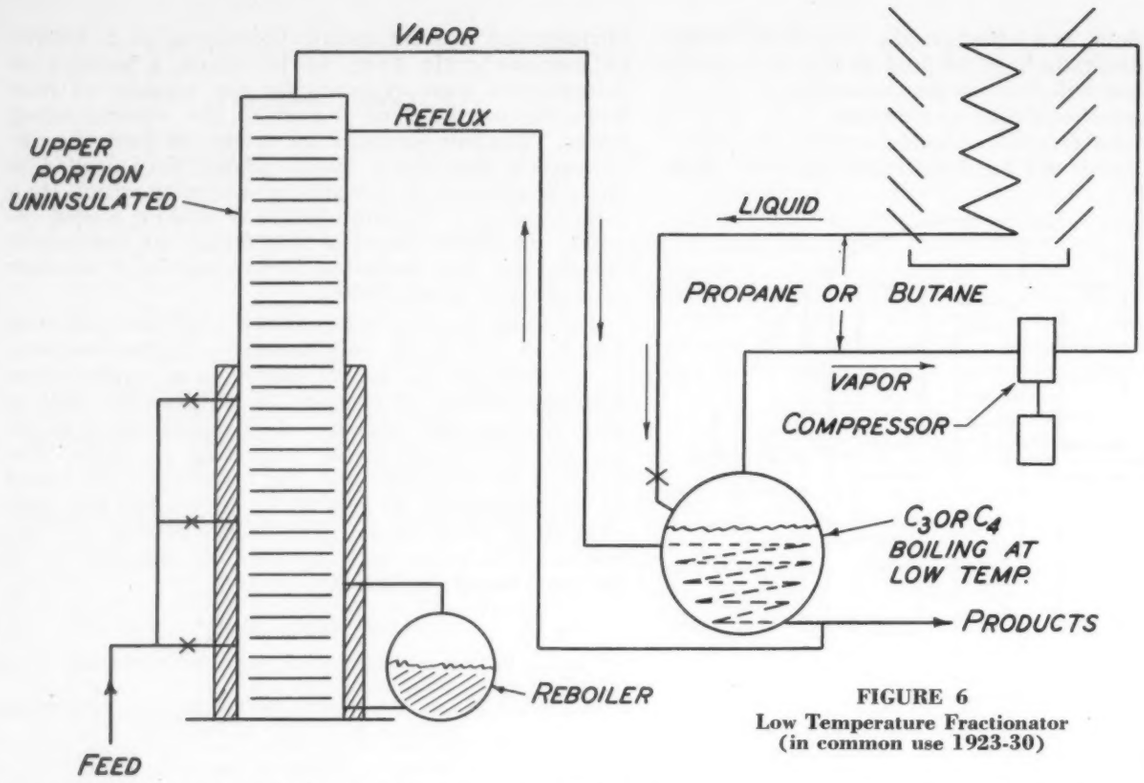

FIGURE 6
Low Temperature Fractionator (in common use 1923-30)

sure or bubble point of the reflux at 100° F. This vapor pressure would be calculated as follows:

	Mol fraction		Vapor pressure	Partial pressure
Propane	.50	×	188 =	94.0
N Butane	.50	×	53 =	26.5
Total pressure, lb./sq. in. absolute.....				120.5

Or 120.5 — 14.7 = 105.8 lbs. per sq. inch gage pressure.

The pressures on column 2 (7a) and column 1 (7b) would be the same, a pressure slightly above the vapor pressure of pure propane at 100° F. or 188 pounds per square inch absolute.

Column 2 (7b) would have a pressure a little higher than 53 pounds per square inch absolute, the vapor pressure of normal butane at 100° F. This advantage in reduction of pumping equipment costs in the case of 7b is small, however, in comparison with the saving in fractionator and steam cost as column 1 (7a) will necessarily have to be designed to handle twice the vapor, heating and overhead condensing load that column 1 (7b) would require.

Better control of the reflux ratio can be had by placing the condensers for the overhead vapor near the ground level. Some of the earlier columns were equipped with the condenser placed on top of the tower, having a weir adjustment to control the reflux rate back into the tower by gravitation. Operators seldom climbed to the top of such columns to see how well the reflux flow was under control.

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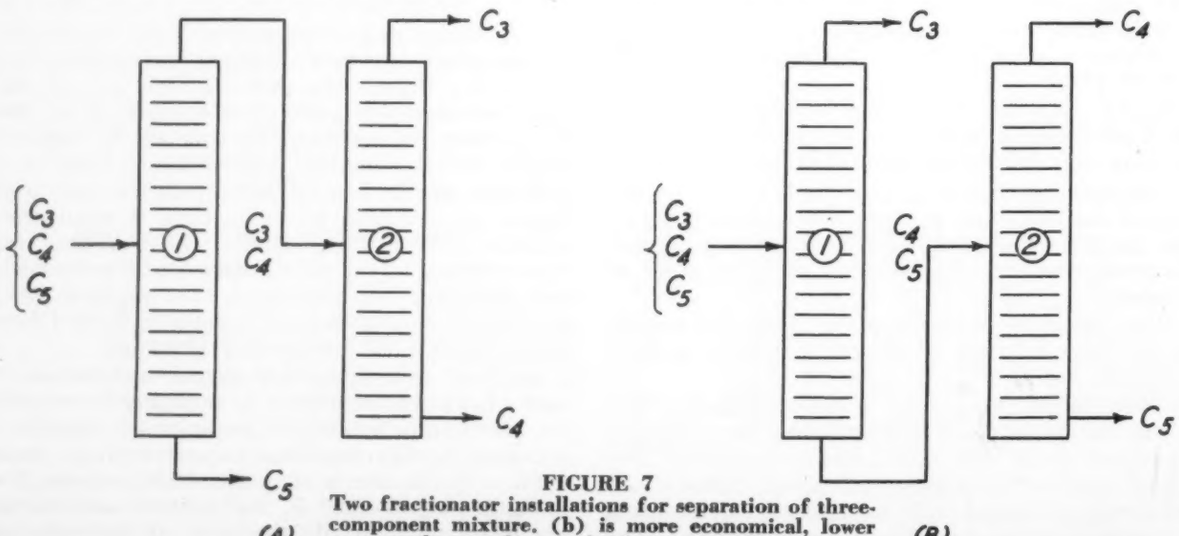


FIGURE 7
Two fractionator installations for separation of three-component mixture. (b) is more economical, lower heat and vapor loads in tower (1).

Welding Procedure and Practice for Mild Steel

WELDON L. ARCHER

THE many applications of welding in the modern refinery are so taken for granted that few men realize that just 15 years ago welding was a new-born baby. Notwithstanding the many restrictions placed upon the growth of this baby in an effort to lean over backwards in the promotion of safety, welding has reached a healthy majority.

There is no question that the present status of welding in industry owes much to the refiners and others in the oil industry. Perhaps the refiners were driven by higher operating pressures and temperatures to an early acceptance of welding. Then, too, the lower cost of the welded unit must have had some influence. Whatever the cause history tells us that the processing division of the petroleum industry pioneered the change from riveted to forge welded to fusion welded construction.

Mild steel constitutes the base metal used in most of the refinery applications of welding. This material is found in the three main divisions of use: piping, pressure vessels and storage tanks. Most of the mild steel has been fabricated by an outside source with the operator's welding activity confined to maintenance work and changes. But for the sake of thoroughness we will consider mild steel as it is fabricated in the welding fabricator's shop as well as in its role in the refinery.

What is mild steel? This is a term that is given to a low carbon steel containing small amounts of manganese, phosphorus and sulfur. All four of these elements represent impurities in iron. But impurities seems to be an ill-chosen term when we consider that about ¾ of 1 percent of these "so-called" impurities raises the strength of iron from 42,000 psi to 55,000 psi. As long as we keep the carbon, manganese, phosphorus and sulfur within certain well-defined limits, it is a good idea to have them around.

Through the medium of the API-ASME code the refiner has been relieved of the necessity for setting steel specifications. In addition this code has taken care of the problems of design, construction and inspection. All that remains for the purchaser of refinery equipment to do is picking and choosing among some of the alternates allowed under this code. And the first point to consider is steel.

Three grades of mild steel are available under the code for pressure vessels: ASTM A10-39 and ASTM A70-39, the last being divided into flange and firebox grades. There is little difference in these steels other than physical tests and inspection at the mill. ASTM A10-39 must be tested to guarantee that the analysis and strength of the entire heat is proper. Since a heat may well run from 100 to 200 tons, this does not tell us much about a bad ingot or slab that might have been included in the heat. Rare indeed is the production of inferior steel under this specification but inexpensive insurance is available. All of the large oil companies have invested in such insurance.

This insurance is the use of ASTM A70-39 steel in the firebox grade for all plates and heads. For only 20 cents per 100 pounds the consumer gets physical tests on each slab with the tensile test taken from both the top and the bottom of the slab guaranteeing sufficient cropping of unwholesome metal at the mill. Added to these tests is the homogeneity test which was designed to reveal any structural irregularities in the steel. From the standpoint of quality the steel user gets a lot for his 20 cents. But that is not all. The code (the term API-ASME will be understood to belong in front of the word code but will be omitted for brevity) recognizes the higher quality of this steel and allows a greater joint efficiency where it is used. Thus there are cases where the more expensive quality steel actually saved in overall cost due to lessened shell thickness.

Other material choices may be made to cover piping and forgings but the need for careful choice is less important in these instances. Forgings will be of high quality when used as specified by the code. Pipe might well be restricted to seamless, insofar as possible, because of the tendency of welding to pull the mill-made butt and lap welds open. Not often does this happen but bad luck with a key bit of piping might lead to a needless delay.

Now there are other choices that may be made among welding processes, types of fittings, and so on. Still we have made little advance from the philosophy of the ancients who felt that the reputation of the maker was the best guarantee of quality. Reputable fabricators are well versed in code requirements and may be relied upon to produce good work in accordance with recognized standards. Some attention must be paid by the purchaser to the amount of research and control equipment used by the fabricator because welding under close supervision is just enough better to be worth a small premium.

Inspection is done in one of two manners: by a representative of the purchaser or by a representative of an insurance company regularly engaged in such inspection work. Either method is satisfactory although most of the large companies maintain their own inspection service.

So much for the purchase of refinery equipment. By following the code and ordering all work inspected as well as manufactured in accordance with code regulations the purchaser is certain to get the best in welded vessels. Starting with good equipment, it is up to the refiner to maintain his units at a high level. This he does by welding.

Unfortunately in the rapid advance of welding many executives have been unable to keep pace with the numerous improvements. Even worse, though, is the lack of appreciation of the need for excellent

supervision of welding work being done about the refinery. Safety requires the best welding possible; economy demands the best practice. And the executive should know enough about welding to make sure that he is getting both.

Welding serves three distinct purposes in maintenance: one, the repair of cracks; two, the making of changes in openings; and, three, the building up of corroded areas. New work might include piping installations and the lining of vessels, with the latter procedure combining maintenance and new work.

FIGURE 1
Crack in Plate Material

Bearing in mind that we are talking about mild steel, consider the maintenance work. Cracks, which represent the most difficult repair work, will be considered first. In general cracks are divided into two types: those that go but a short distance into the plate and those that go through the plate. These two types are illustrated in Figures 1 and 2.

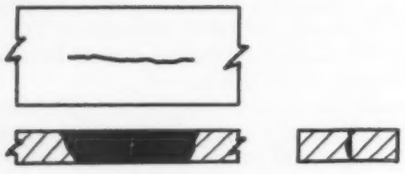


FIGURE 2
Through Crack in Plate

Before a repair may be made the crack must be removed. There are two satisfactory methods of removal with preference being given to chipping with a diamond-point chisel in a pneumatic gun or the very latest scheme which calls for melting the crack out with the oxy-acetylene gouging torch. Where speed is essential, the latter method will prove to be at least five times faster than chipping.

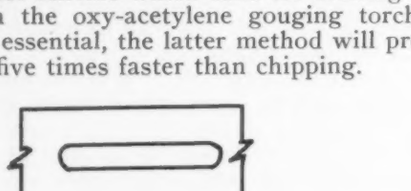


FIGURE 3
Groove for Crack Repair

The contour of the grooves is shown in Figures 3 and 4. Both the sides and the ends of the grooves must have sufficient slope to allow proper manipulation of the electrode. In repairs of this nature it is poor economy to attempt a very narrow groove which may be welded with small electrodes. The savings in electrodes may be offset by a poor weld or by a large increase in the time required to make the weld.

Note that the plate material furnishes the bottom of the welding groove in Figure 3 whereas a backing strip must be employed in Figure 4 where the crack went completely through the plate. The backing strip should be large enough to extend no less than ⅜-inch beyond the ends and sides of the welding groove. The thickness may be a minimum of ¼-inch. Wherever both sides of the weld are accessible, the backing strip should be removed and the weld completed from the second side. Where the backing strip is to be left in place, extreme care in welding this strip to the plate is needed to get a perfect job.

If the thickness of the plate material is less than 1 inch, the prepared groove is ready for welding. The first few passes will heat the plate to a good temperature to prevent further cracking. But should the plate material exceed 1 inch in thickness, rapid removal of heat from the weld and fusion zone may cause trouble. In this case heating to 300° F. to 400° F. is a wise precaution. Not only will this preheat minimize the danger of cracking the weld but also will it prevent the loss of ductility in the heat-affected zone. The time-honored method of heating until water is rapidly boiled from the surface is a good enough indication of the temperature.

Most pressure vessels are stress relieved. The welding operation introduces stresses into the structure that may be removed by heating at an elevated temperature for a specified period. The code specifies this treatment in detail.

These same stresses are bound to be present in the crack repair with even more danger existing because of the localized nature of such a weld. The patch cannot be stress-relieved. But too great concentration of stresses can be avoided by peening. A rounded peening tool in the air gun will stretch the weld metal and relieve stresses. All this peening must be done while the deposit is still hot, never when the weld has cooled. Cold working the weld may do more harm than no peening at all.

A word about electrodes is in order. Most repairs are made with a reverse polarity organic coated electrode of the all-position type. Suppliers can give the name of the electrode that meets these requirements. Usually this electrode comes in two types with a heavy and a light coating. For vertical and overhead patches use the light coating; for horizontal and downhand welding specify the heavy coating. If the electrode has an intermediate thickness of coating for all purpose work, no choice is necessary. Nor is it necessary to test the physical properties of the electrode. If the deposit will satisfy the requirements of the American Welding Society's grade 10, that is all needed. Any large electrode manufacturer can supply this material.

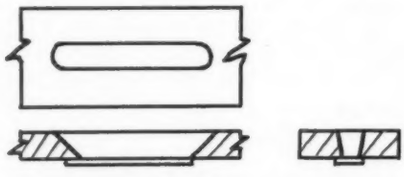


FIGURE 4
Groove and Backing Strip for Through Crack Repair

Just as too small an electrode is a mistake, so is too large an electrode. The size of the electrode should be suited to the position of the work and the width of the groove. Usually all work that is not strictly positioned for downhand welding must be done with electrodes of 3/16-inch maximum diameter. For wide grooves these electrodes must be oscillated, holding such oscillations to a width no greater than four diameters of the electrode. Where excessively

wide welds must be made, parallel deposits will reduce the width of the oscillation.

This procedure will lead to satisfactory welded repairs in every respect as good as the original vessel material. Perhaps because of the greater corrosion resistance of the weld deposit, the repair might be considered to be better than the original plate.

Sometimes a change in operating procedure calls for the plugging of an opening in a vessel. Very often it is desired to remove a nozzle from a vessel as, for

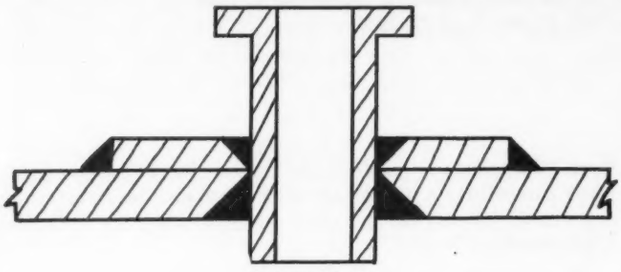


FIGURE 5
Nozzle to Be Removed

example, the fitting shown in Figure 5. This is cut out with the cutting torch and replaced with a plug as shown in Figure 6. Both plug and edges of the patch are bevelled with the torch to facilitate the welding.

As far as the welding operation is concerned, the rules given for the welding of the crack will suffice for this weld. Preheating, when necessary, and peening are essential operations. A word of caution regarding the peening might be introduced. Never peen the first two passes of a weld, unless it has substantial backing as in Figure 3 or the second side of Figure 6.

That brings up one extra operation necessary for a good weld as shown in Figure 6. The root of a

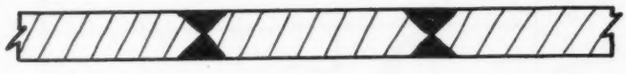


FIGURE 6
Patch Replaces Nozzle

closed vee offers stubborn resistance to fusion. When the first side of such a weld has been finished, the second side must be chipped until sound weld metal is reached. This operation is just as necessary in a patch as it was in the original welds in the vessel.

Note that in Figure 6 the pad that is shown in Figure 5 has been eliminated. An opening no longer exists and the well made patch is every bit as good as the original vessel plate. Chipping and flush grinding of the weld metal will make the patched place look as good as new.

The last welding maintenance operation we shall consider is the repair of places of erosion or corrosion. Such regions as shown in Figure 7 are built up by stringer beads of weld metal. The base metal may well be sand blasted before the repair weld is made. Otherwise chipping or grinding will prepare the metal for welding. This is done because oil or paint will interfere with the making of a proper repair.

Once more the all position type of electrode with its organic coating is indicated for the work. In some cases of specialized erosion or corrosion stainless steel might be selected for the repair material. Unless the condition is unusually severe, the grade 10 electrode possessing as it does corrosion resistance better than that of the base plate will afford ample protection.

The beads are laid in one direction until the area has been covered; then the slag is removed. At this time any irregular spots are chipped out and patched. Next a series of beads is laid at right angles to the first layer. This procedure is followed until the area has been built to the needed height.

One more word about the code seems in order before closing. There are rules and regulations for the qualification of welding operators in the code. Such qualification is felt to be necessary to a perfect job of welding. And so it is. But what of welding repairs?

Here there are two courses open to the refiner. Either he may contract his repair work out to a welding contractor who has qualified welding operators or he may qualify his own men to do such work. Surely there is as much, if not more, need for good welding by qualified operators on repair work as there was on new work. Perhaps because of the reduction in wall thickness by time, the need for good welding in repairs is even greater.

In addition to the making of qualification test plates, there is another means of checking welding. Practice counts as much here as it does on the field of sport. So we make good use of acid etching for welding control.

Take a heavy plate and pretend that you are patching a crack. Place the plate in a rigidly held vertical position and proceed according to directions with the grooving and subsequent welding operations. Cut some samples out of this plate next. Polish these samples on a grinder until the surface across the weld is fairly smooth. Then place the samples in a mixture of 1:1 muriatic acid and water at 160° F. for

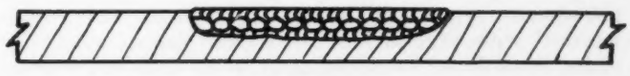


FIGURE 7
Building Up Eroded and Corroded Area by Padding

20 minutes. Brush the scum off the surface and examine the structure.

Such etch tests will make a believer out of the average executive in short order. Where such tests have never been conducted before, the engineer in charge of welding may have a sudden attack of insomnia. And well he should. But prompt consultation with the supplier of welding materials and, in some cases, the acquisition of a good welding foreman, will correct the existing ills in a jiffy.

It is easy to make a good weld. Simple manipulations combined with a certain amount of experience enables the welder to turn out perfect welds day after day under proper supervision. It is up to the management to provide such supervision to bring the quality of welding in and around the refinery to the same level enjoyed by the shops that built the equipment originally.

Now this information may not apply to all refineries. To many of them it does not. But it is the definite responsibility of the operating executive to assure himself of the quality of the welding work he does. Just the other day the assistant chief engineer of a large company showed the writer some sorry looking welds. His inspectors had watched the welding operations and had passed the welders. Neither they nor their superiors realized that the welds were improperly made. The etch test would have told them. When it was too late, it did. And the department of safety demanded an expensive job of re-welding.

Viscosity and Constitution

PROF. DR. GEORGE HUGEL, University of Strassbourg

A Lecture Given at the Meeting of the Society of Petroleum Research, December 8, 1938
(Translated from Oel u. Kohle, Vol. 15, No. 2, p. 27, 1939)

DURING the course of my researches concerning viscosity of oils, it has repeatedly occurred to me as to whether our fundamental knowledge on this subject is sufficiently accurate for further application to technology.

Structural formulae have been derived, as it were, by way of chemical syntheses—chemical reactions, many of which deal with quite energetic changes within the molecule itself. From a purely chemical viewpoint, such derived formulae tell us only what is the maximum quantity of reaction—products one can expect in the usual type of reaction. For instance, the formula for propane tells us that in the chlorination for monochloro derivatives one can expect a maximum of two monochloro-propane molecules.

For comparison, let us study the occurrence of flow phenomena in a liquid: energy equivalents with which we deal with here are of a different and of a smaller order than those found to exist in an ordinary chemical reaction. No doubt this state or condition depends also upon the reciprocal collision of molecules as in chemical reactions. There is, however, an important difference not to be overlooked. In the case of reactions only those collisions of molecules enter the picture which have been energetically activated, while in flow phenomena similar collisions have to be dealt with but while such molecules may not be excited or activated, nevertheless, they most always carry some high energy level.

It appears to me, therefore, that perhaps important characteristics of chemical constitution can have little or no bearing or influence upon the property of liquids called viscosity.

First, I would desire to illustrate this with a few examples.

In Figure 1, I have plotted the vis-temperature curve of three substances of very different chemical constitution: dihydro-di-iso-amyl anthracene, butandiol, and n-octane.

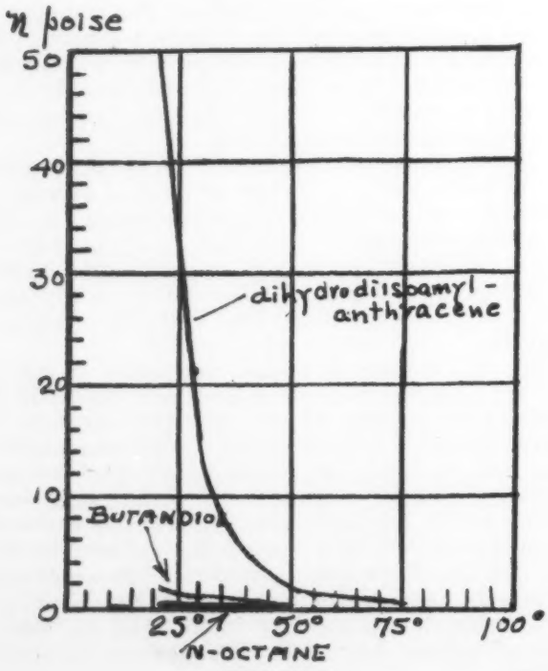


FIGURE 1

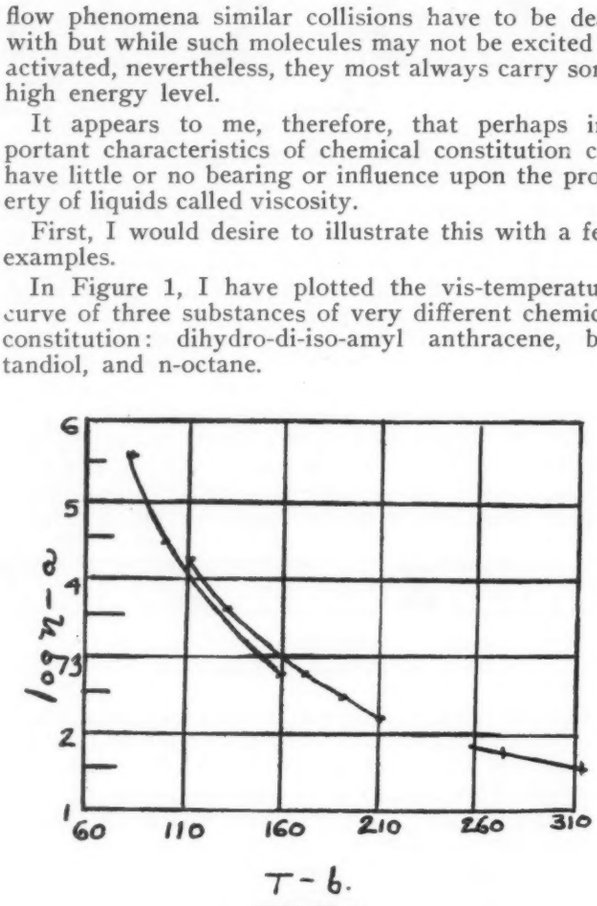


FIGURE 2

Structurally, these compounds certainly have nothing in common; the molecular weights are very different, butandiol with the smallest, and the anthracene derivative many times greater; butandiol contains two alcohol groups, octane is a simple open-chain hydrocarbon, the anthracene being a fairly complicated molecule; butandiol associates strongly; octane is a completely normal liquid—and no doubt dihydro-di-iso-amyl anthracene is to be looked upon as an associated compound. As ordinarily plotted, the visc-temp curves are also quite different. In general it can be seen how rapidly the viscosity decreases with rise in temperature in the case of dihydro-di-iso-amyl anthracene.

When these curves are mathematically plotted—logarithmically for instance, all three visc-temperature curves are almost identical—there are three dif-

ferent parts of apparently one and the same curve, as we see in Figure 2.

The curve is hyperbolic, asymptotes bent to the right, and which is expressed:

$$U \times W = C$$
where $U = \log_n - a$
and $W = T - b$

$\log_m$ is the logarithm of the viscosity-factor T, the absolute temperature: a, b, and C are constants. In Figure 2 the ordinate is $U = \log_n - a$, the abscissa is W=T—b. The fact, that the constant C is practically the same in all three cases proves that the three parts are or belong to one and the same curve.

TABLE 1

	C	a	b
Dihydrodiisoamylanthracene	449.5	—2.8225	211.8
Butandiol	472.7	—3.6340	161.0
n-octane	463.5	—3.8500	0.0

It is seen that nothing was done in these graphs except to shift the co-ordinate scales. The result obtained shows that n-octane describes the same curve at a lower temperature which is identical for the curve of dihydrodiisoamylanthracene at a somewhat higher temperature. In other words, these three very different chemical compounds possess practically one and the same curve for the visc-temp relationship; the only difference is that the curve for the three substances will be crossed at different temperatures.

It is therefore to be pointed out that care must be exercised at all times in connecting the vis-temp relationship of a substance with its constitution. One can clarify the picture as follows: n-octane at the lower temperatures possesses a lower density than dihydrodiisoamylanthracene at equal viscosity. From this one arrives at the following comparison:

N-octane has:
at equal viscosity
a larger volume,
smaller molecules
lower temperature
than
dihydrodi-iso-amylanthracene which has:
at equal viscosity
a smaller volume
larger molecules
and a higher temperature

It is certain that a real difference in the vis-temp curve does not exist between associated and normal fluids. The different conditions in which the curve for the three substances will become crossed are expressed in the constants a and b, as is seen from Table I. For instance, b signifies nothing more than that viscosity of the anthracene compound and of the butandiol is already infinitely large before reaching the absolute zero point. The whole difference between the three substances resides in the constant a. We must next interpret the constitutional properties which reside in the constants a and C.

For this purpose we will confine ourselves next with the simplest organic liquids, where b=o. We can write the equation for viscosity-coefficient in somewhat changed form, as follows:

$$n = Ao \frac{Q}{RT_1}$$

Where n is the visc-coefficient, A and Q are constants, which are connected with the above-mentioned constants a and C by the following expressions:

$$\log A = a$$
$$\frac{Q}{R} = C_1$$

where R is the gas constant, T, the absolute temperature; this formula was first derived by Drucker, and later revived by Andrade, Sheppard and Raman.

We will now determine the range of value or usefulness which is inherent in this equation; the following substances belong to this equation:

1. aliphatic hydrocarbons
2. monocyclic hydrocarbons
3. Lower alcohols to C_8
4. Ketones
5. Low molecular weight esters
6. Low molecular weight acids
7. Halogen derivatives.

The Drucker formula does not hold for the following:

1. polycyclic hydrocarbons
2. higher alcohols, acids, and esters
3. polyalcohols and esters
   and in general all substances which contain several chemical substituents in one molecule.

We will compare now with one another the values of a and Q, which we can compute for the above substances by the use of this formula. Plotting the value of Q as the ordinate is a right-handed co-ordinate system, and a on the abscissa, it can be seen from Figure 3 that a large number of substances will fall on a straight line indicating the close relationship of these substances based on viscosimetric standards. It will be found, moreover, that chemically different substances such as open-chain hydrocarbons, cyclic-hydrocarbons, ketones, and esters all lie very close together on this curve.

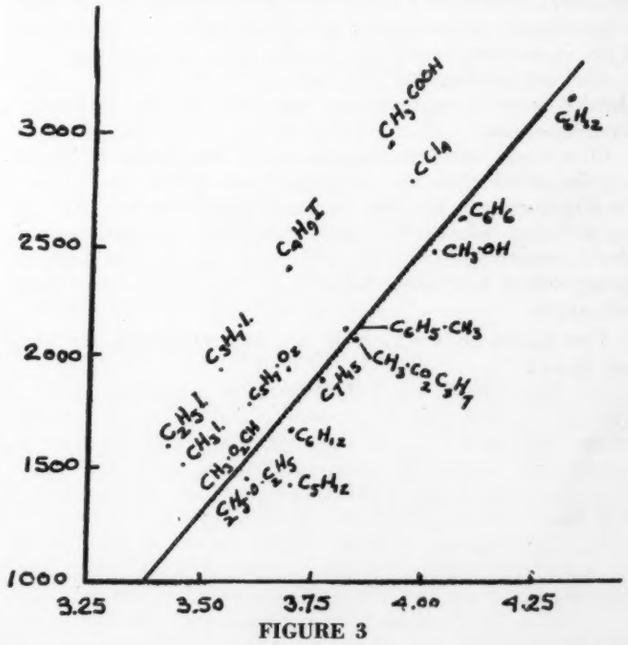


FIGURE 3

If A has the value of a viscosity at an extremely high temperature, one can write for A:

$$A = A_o H$$

dependent on the linear relationship of a and Q; here A_o is a common member, containing the greater

percentage of substance A, of the above named several fluids. In H reside the constitutional, specific characteristics of the substance, which are on percent-basis representing the lesser or smaller portion. Dunstan's law is a derivation of this. According to this law lg_n is represented as a linear function of the mixture. At the same time, we also derive the similar logarithmic increment which holds true in whatever homologous series we wish to ascend.

It is concluded from these relationships that these substances relate back, from a viscosity standpoint, to a common primal or basic fluid substance. The regularity of basic units in the molecules of all substances is also evidently the same or at least very similar. The constitutional properties produce only a small or very minute change. From which follow again precise statements that can be made concerning association in those fluids which follow Drucker's law.

The ketones, for instance, have always been classed as abnormal fluids. Judged from their visc-temp curves, they behave as fully normal liquids. It is desirable to consider this property of the ketones a little more fully. The degree of association of ketones had been determined, and a value of nearly two has been calculated, for instance, for acetone. A somewhat lower degree of association has been found for methyl-ethyl ketone. Assuming we have an unsaturated hydrocarbon C_6H_{12}, and we desire to compare it with the unsaturated C_7H_{14}. According to Dunstan we then determine for 20° C, the logarithmic increment for the increase in viscosity, which is produced by a CH_2 group. If we now polymerize C_6H_{12} to $C_{12}H_{24}$ and likewise C_7H_{14} to $C_{14}H_{28}$, then we obtain a log increment for viscosity increase from C_{12} to C_{14}, which is twice the value of a CH_2 group. The associated molecules are evidently less stably bound. One can nevertheless expect that the degree of association can be brought into expression in the logarithmic increment due to increase of viscosity. This is not so, however, in the case of ketones.

The log increment of viscosity for a CH_2 group in the ketones is exactly the same as for the aliphatic hydrocarbons.

One must so view association of the ketones keeping in mind that the arrangement of the molecules be the same as in their respective hydrocarbons, up to a point where different densities alter some of their properties, and that the presence of a ketone group does not introduce any new basic principle whatever.

For substances which do not follow Drucker's law, we have:

$$b \pm o$$

Drucker's formula is now transposed in:

$$N = A_e^{\frac{Q}{R(T-b)}}$$

This formula was also derived already by Andrade.

Placing again the values of a and Q into the coordinate graph (as was done above) it will be seen that the substances do not fall onto the same curve, and that the dioles, for instance, with their terminal alcohol groups, produce a fairly definite new type of curve.

In summarizing, it is seen that the arrangement of the molecules is different for these abnormal substances but remains the same in a homolgous series, as in the diols. There are other phases which are quite numerous, nevertheless. The diols do not fall on a straight line according to molecular weight. This is clearly shown in the value of Q as shown in Table 2 below.

TABLE 2
Value of Q

Glycol	1962
Propandiol	2568
Butandiol	2161
Pentandiol	3635
Hexandiol	3170
Decandiol	2205

The values of Q increase, decreasing again from decandiol onward. This signifies that (since Q and C are equal as to the constant value) with increasing molecular weight the vise-temp curve is at first flat, finally falling off at a steep incline.

With increasing molecular weight the association-aggregates become more stable, and perhaps with pentandiol reach a maximum stability. The value of Q does not, in general increase with any regularity.

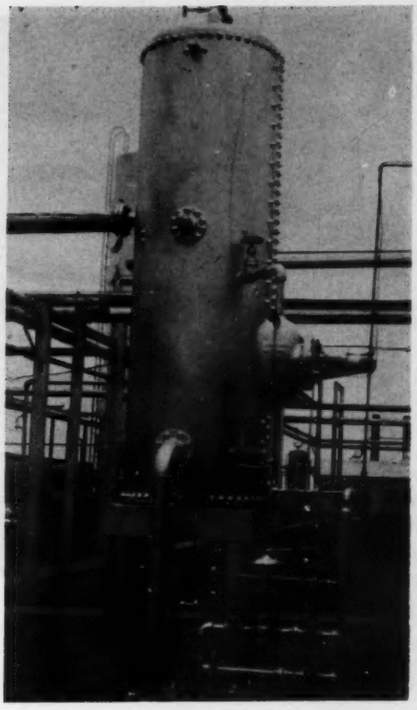
The value of Q is larger, in the case of diols with odd number of carbon atoms, than for the primary compound with an even number of carbon atoms. The association complexes of diols with odd number of carbons are more stable than those containing an even number of carbon atoms. Viewing the molecule as made up of electrically charged atoms, the following picture will then reveal the reason for the above statement.

$$\underset{}{\overset{-}{HO}}\ \overset{+}{CH_2}\ \overset{-}{CH_2}\ \overset{+}{OH} \qquad \underset{}{\overset{-}{HO}}\ \overset{+}{CH_2}\ \overset{-}{CH_2}\ \overset{+}{CH_2}\ \overset{-}{OH}$$

GLYCOL

In the case of propandiol, for instance, the hydroxy ends are negatively charged, while with the glycol the charge is variable; the latter indicates a molecule which is electrically excited. This is the reason also why the associated molecules of glycol are less stably bound.

Fractionation Concentrated At One Plant



Constant delivery into the pipe line without slugging is accomplished by liquid level control on the accumulator tank.

SINCE Skelly Oil Company revised its method of handling natural gasoline in Osage County by grouping all fractionating equipment at the Lyman plant, the gasoline manufactured in other plants in this field is pumped to tanks at Lyman through a single pipe line. As a large amount of the raw natural received at the special equipment is separated into many specialized products, the feed to the fractionators must be reasonably constant in composition.

Due to a pressure-maintenance program in effect at the south end of the field, the gas is received at three plants at different pressures. This situation makes it necessary to employ two-stage compression and likewise requires high- and low-pressure absorption. In order that maximum extraction may be obtained, particular attention is given the condition of the absorption oil and the blending of the vapor-recovery gasoline with the absorption product in the proportion of volume.

The absorption oil reconditioning units are designed for split-stream operation, using only a small amount of the oil circulated in the high- and low-pressure absorbers, but adjusted so the entire amount of oil in the systems can be cleared up in 10 days.

The absorption oil stills are set horizontally with "I" beams welded directly to the sides of the shells so they can be placed over brick-lined furnaces, but suspended upon vertical pipe supports. Heating is obtained by gas-fired burners. Each unit is provided with a vapor dome welded to the top of the still, equipped with a bolted companion flange for the vapor outlet piping.

Oil Reconditioning

The vapor piping installed to the companion flange of the vapor dome consists of 2 feet of 6-inch pipe with side branches for two safety valves for the release of vapors when pressures build up above the safe working pressure of the system. The piping which carries the vapors from this 6-inch pipe, and performs some of the functions of a dephlegmator, is 2-inch screwed pipe connected at the other end to the vapor condensers.

The oil which is being reconditioned flows to the still under lean-oil-circulation pressure and is admitted to the still through a float box-operated inlet valve to maintain the required level of the fluid in the still. Heating is obtained with hand control on the burner adjustment valve instead of using a thermometer controller, because the volume of oil flowing into the still is governed by the amount distilled.

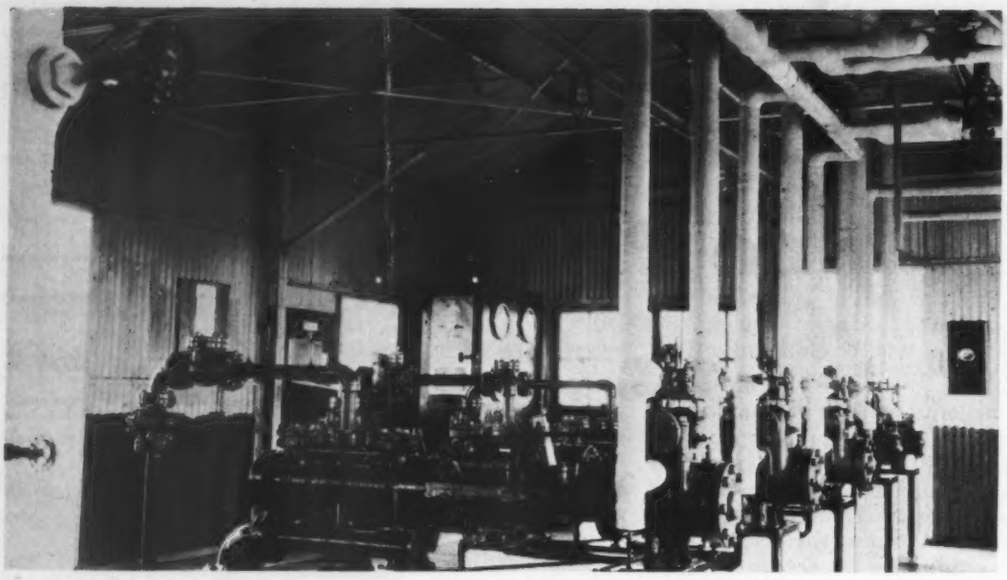
As the oil distillation systems are operated at atmospheric pressure, it is necessary that the reconditioned oil be pumped back into the absorbing stream. The accumulator for the reconditioned oil is located near the absorber columns so the stillman may observe its operation and as frequently as necessary drain water from the drum. The accumulator is equipped with a liquid-level valve, remotely connected to the throttle of a small reciprocating steam pump which removes the accumulated reconditioned absorption oil at the rate at which it is condensed without attention of the plant operator.

The reconditioning unit is placed on stream as frequently as conditions of the absorption oil warrants and may be operated continuously, or intermittently. The oil is never permitted to become black and full of heavy ends, but is kept clear and as near its original condition as possible.

Vapor Recovery

The gasoline manufactured by high- and low-pressure absorption contains all fractions originally in the gas that may be used for blending for motor fuel or for liquefied petroleum products. The gross production therefore, has a high vapor pressure and vapors are continuously being released from the accumulator tank and plant storage. Engines equipped with recompressor cylinders are used to recover these vapors which are reduced to a liquid state by direct compression and cooling.

Two methods are employed in the Burbank plants for blending the recompression gasoline with the absorption gasoline to obtain closely controlled composition for pipe line shipment. That used at the Fairfax plant, No. 1, is obtained by pumping the recompression gasoline directly into the pipe line as it is manufactured. The recompressor accumulator at



The second pump in this battery is hooked up to the accumulator tank by remote control for continuous delivery of gasoline to the pipe line without slugging with other products.

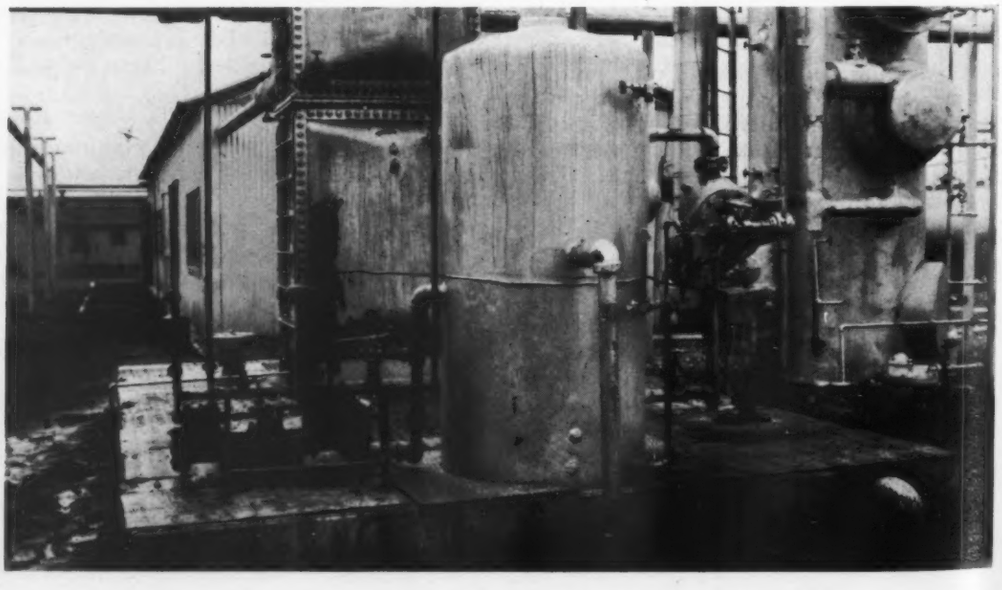
this plant is equipped with a float-controlled instrument on the side of the accumulator which operates a reciprocating steam pump.

As the gasoline made at each plant is pumped into the pipe line at a constant predetermined rate, the introduction of recompressor gasoline blends the two grades in proportions equal to their respective volumes without slugging the line with first one grade and then another. The tanks used for storage are gauged on the same hour each morning and turned into the pumping-out pump immediately. The pumping-out pump is regulated to pump at a rate which moves the production of the previous day at about the time the gauges are taken so there will be a smooth flow of gasoline at all hours.

Blending Control

The method used for blending the recompressor gasoline with the absorption product at Fairfax No. 2 plant consists of controlling the flow of liquid from the recompressor accumulator with a liquid-level instrument which operates a valve on the outlet piping. This line is connected to the line leading from the absorption accumulator to storage tanks and allows the recompressor gasoline to expand into the absorption gasoline, thus reducing the temperature as the liquid enters the storage vessels. When this process is used, the temperature of the blended gasoline averages as much as 20° F. lower in the storage tanks than the absorption gasoline in the accumulator tanks. The reduction in temperature reduces the amount of vapors recycled through the recompressor engine, and blends the two grades of gasoline satisfactorily.

At the Lyman plant, where the stream of composite gasoline is received from the three other plants the product is near uniform in composition because of the method followed when blending and pumping into the pipe line. Because of the constant composition of the gasoline received at the special fractionators, the completed products are uniform in quality, and the columns when once placed in equilibrium, do not require frequent adjustment of temperature, pressure and reflux control.



Automatic accumulator tank for absorption oil from the reconditioning still and for delivery of renewed oil into the absorption system.

Suspended Walls*

H. O. JOHANSON, M. H. Detrich Company

THE use of refractories for furnace construction is as old as the science of steam engineering. The first boilers were set over brick furnaces, but more than a century ago attempts were made to substitute water-cooled steel furnaces in place of refractory ones. John Steven's locomotive built in 1825 was equipped, not only with a water-tube boiler, but also a water-cooled furnace.

The necessity of conserving space and weight made the water-cooled furnace popular in locomotive and marine practice, however marine practice is now leaning toward water-tube boilers and refractory-lined furnaces.

Such cycles are typical of all engineering developments. The practice of today may differ from that of the past decade but be similar to that of 50 years ago, yet in all cases be based on sound reasoning. Engineering is the commercial application of scientific principles for the benefit of mankind. Without the commercial consideration it becomes research and development by experiment. There are consequently several roads to engineering success. These paths differ because they start at different points, and the commercial conditions differ at each of these starting points. The straightening of one road stimulates the improvement of the other; the development of oil-fuel-firing equipment has encouraged stoker improvements and the success of water-cooled furnace has pointed out lines of improvement in refractory-lined furnaces.

Refractory-lined furnaces are universally used in refinery furnace construction today, both in connection with oil stills and boilers.

There are five reasons, any one of which may cause the failure of a refactory lined wall. They are: (1) melting, (2) softening, (3) spalling, (4) fluxing, and (5) expansion.

Suspended walls greatly reduce, and in many cases entirely eliminate, the causes of these failures, and that is why today most refinery oil stills and boilers are installed with suspended walls.

Melting

There are very few cases of failure by melting, as the better grades of fire brick will not melt under any but extremely high furnace temperatures. A suspended wall with a thin refractory lining allows a chance for external cooling which greatly reduces melting failures. Many failures that appear to be melting are in fact fluxing, which will be discussed later.

Softening is a far more frequent cause for trouble; in fact one of the major causes as softening often occurs at a very low temperature. Brick softens near the bottom of a furnace and this is usually the hottest point. Softening reduces the carrying capacity of the brick, and the inner surface of the furnace is hence inadequately supported and gradually leans inward and eventually falls unless frequently repaired.

Air-cooled suspended walls improve this condition, as sufficient heat is carried away to keep the inner surface of the brick below the softening temperature. Further, there is not sufficient weight on any one tile to produce deformation if high furnace temperature tends toward softening. Brick has a low heat conductivity which necessitates that air-cooled walls be thin, as a thick wall will not permit sufficient radiation to have an appreciable cooling effect on the inner surface. Probably 9 or 10 inches is the maximum thickness with which air cooling is effective.

Spalling

When some refractories are alternately heated and cooled the expansion and contraction causes a mechanical failure with particles of brick falling away, leaving a ragged surface. This action is known as spalling. It is easily recognized because the brick surface has the appearance of having been broken away with a metal tool.

A suspended wall greatly reduces spalling failures because sectionalization takes all load of the refractories and flexible suspension allows them to come and go without strains being set up.

Fluxing

When fire brick flows, it is seldom due to melting, but generally because the chemical composition of the ash is such as to act as a flux and as fast as the ash comes in contact with the brick the latter is washed away. Such an action will continue in some cases until in spots less than one brick's thickness remains. If this spot is small, and at a point which carries no great wall load, the brick will remain indefinitely without further thinning. This phenomenon is due to the fact that the thin brick can now carry the heat away so rapidly that the inner surface becomes so cool that the fluxing action can no longer continue—the surface is at the tempertaure at which the ash solidifies. Solid ash cannot act as a flux and the action ceases.

Air-cooled walls, except under extreme conditions, correct this trouble. An increase in excess air, and consequently lowering of furnace temperature, is

*Before the meeting of the Ark-La-Tex Division, Western Petroleum Refiners Association Eldorado, Arkansas, July 12, 1940.

another remedy, but with solid walls only with so high a percentage of excess air that the resulting stack loss is so high that boiler efficiency is ridiculously low.

An ash that fuses below 2100° F. will cause trouble with any refractory wall unless burned with about 40 percent excess air. Air cooling alone will not suffice.

Expansion

With the best of fire brick the coefficient of expansion, although very low, is a factor that must be provided for. From an expansion standpoint the wall is monolithic because the bricks cannot move individually. Expansion joints must, therefore, be provided. Many types have been designed, each meeting with indifferent success.

Expansion difficulties are not experienced with suspended walls, as each section of wall is independent of all other sections.

Sectional Supported Walls

The sectionally suspended wall was developed to prevent the failures peculiar to solid fire brick walls which we have already discussed. It was also necessary to give consideration to other factor if the design was to be commercially satisfactory. Such a wall must be relatively low cost, simply erected, easily repaired, and readily applicable to air cooling and to insulation. The air-cooling point is of great importance, as in some furnaces the cooling air must be recovered for high efficiency. The cooling air varies in quantity and desired temperature; it is sometimes primary air and sometimes secondary, and sometimes goes to wind boxes. Air passages must at times be large, at others small, sometimes horizontal, sometimes vertical and often a combination of both.

The insulating point is also of great importance, as the wall must be so designed that insulation can easily be attached to the back of the tile to reduce heat losses when the air cooling is of no advantage. When walls are insulated, particular thought must be given to the temperature of the casting or steel holding member.

The castings should be good for two or three hundred degrees more than ordinary grey iron and have non-growth properties at constant high temperatures. For certain extremely high temperature installations a still higher grade of casting must be used.

Boilers

In the past a boiler and boiler setting to many refineries has been a necessary evil and was treated as such. Most of the settings were too small, and with a demand for increased capacity refractories were receiving severe punishment. During the past few years more thought has been given to this equipment, as it is a necessary and vital piece of equipment in the processing of oil.

Today refiners are installing better boiler settings than in the past, and in all but a few cases are using suspended walls for the setting, as the suspended wall requires less maintenance and hence less down time.

Gas and oil is the natural fuel for a refiner to use, and both fuels are easy on brickwork as they do not slag nor cause fluxing. Gas can be fired at a heat release of 35,000 to 40,000 B.T.U. per square foot of furnace volume and oil at 30,000 to 35,000 B.T.U. without harmful effects on the brickwork in suspended walls, especially with modern firing equipment.

The refiner now gives consideration to his boiler setting, so that it will not be the governing factor in the percent of rating, he can safely operate his boiler without frequently repairs or shut downs.

Oil Stills

As air-cooled walls were developed before the insulated wall, the first suspended walls installed on stills were of the air-cooled wall design.

A still, as a rule, had a larger wall area than the average boiler setting, and being fired at a lower furnace temperature had less heat transfer through the refractory which all made the recovery of the preheated air impractical. In many cases the air was dissipated to the atmosphere, which resulted in a small loss in efficiency, so the next step was to insulate the walls to eliminate this loss. The insulated wall has the same suspension principles as the air-cooled wall, but is so designed that insulation can be installed easily and quickly on the back of the refractory lining. A combination of refractory thickness and insulation thickness can be calculated for any given furnace temperature so as to get the economical heat loss through the entire setting. In a refinery where fuel can be had at a reasonable cost, figures prove 2 to 3 inches as the economical thickness of insulation to use behind the refractory lining.

The first suspended insulated walls on stills were on 9-inch refractory thickness with 2 to 4 inches of insulation. The trend has been to reduce the thickness of the refractory lining in stills, as none of the five causes of refractory failures are encountered in an oil still with suspended wall construction.

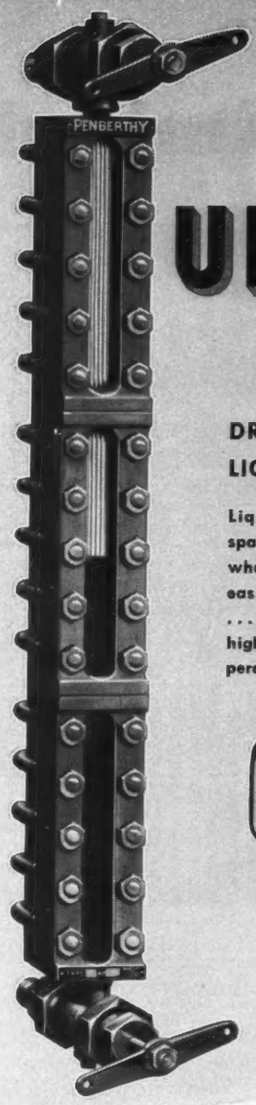
Some of the latest stills are designed with 7-inch refractory thickness on the exposed walls and with 3- or 4½-inch refractory thickness in the walls or arches shaded by tubes. However, some stills have been installed with a 3-inch refractory thickness on both the shaded and exposed walls. The 3- or 4½-inch walls as a rule have approximately 1 inch greater insulation thickness than the heavier walls with about the same over-all heat-loss efficiency.

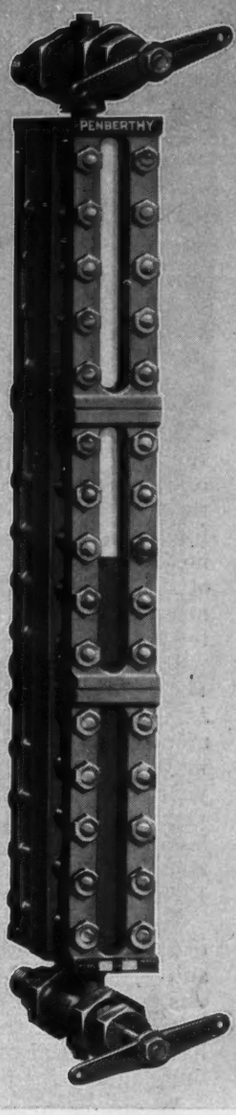
Whereas, the trend of suspended walls for oil stills has been to reduce refractory thickness, the trend in the still design has been to increase the heat release in the furnace proper and to increase the rate of absorption in the coil. The stills of a few years ago had an average heat release of 4000 B.T.U. per square foot of furnace volume. The modern still has a release of nearly 10,000 B.T.U. per square foot of furnace volume; this, of course, has decreased the costs of some of the items such as refractories, foundations and steel on the still.

The refractory furnace has no more outlived it's usefulness than it had when John Steven built his locomotive in 1825. It has its limitations as have all engineering materials. There are no engineering cure-alls.

Suspended wall manufacturers are experimenting on other designs and materials, and will always play a large part in the development and trend of furnace designs.

QUALITY UNCOMPROMISED





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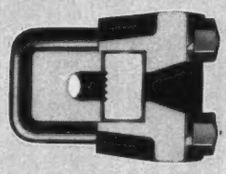

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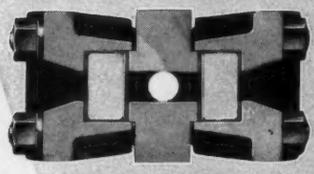

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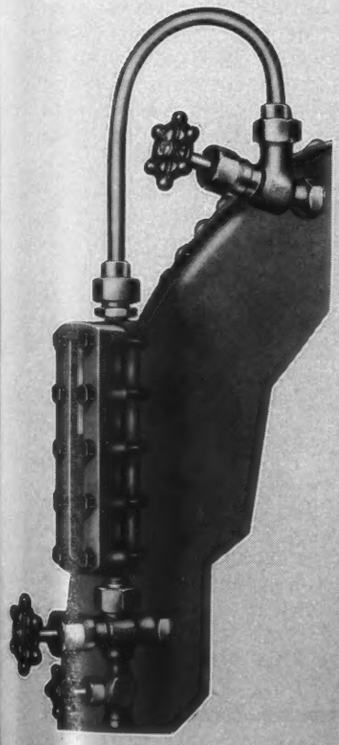

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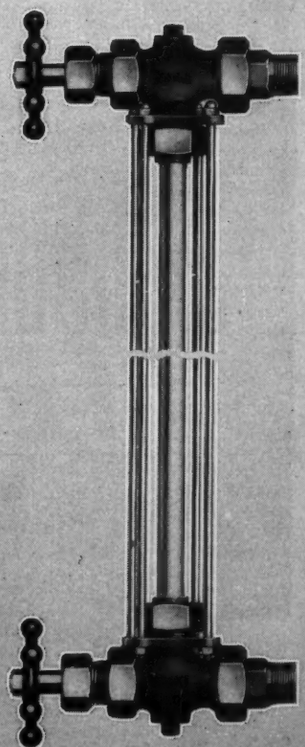

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Surplus Gasoline and Limited Exports Chief Handicaps

L. J. LOGAN

ABOUT 20 oil companies have reported their earnings for the second quarter as well as the first three months of 1940, and the information affords a yardstick for measuring results in the initial half of the year. The figures also throw more light on prospects for the latter half of 1940.

Profits of the group in the first six months of 1940 were over twice as large as in the corresponding months of 1939 and closely approximated the earnings for the whole year 1939. The first-half results this year were among the best in the history of the industry, having been comparable with those in 1937 and 1929.

However, the extraordinary record for the first half of 1940 resulted largely from the advantageous conditions that prevailed in the initial quarter, the second quarter having failed to equal the first in opportunity for profit.

While earnings in the second quarter of 1940 were substantially better than in the second quarter of 1939, they fell somewhat short of the profits in the first quarter of 1940. That decline from the first to the second quarter of this year was contraseasonal, the June quarter usually being more profitable than the March quarter, because of better weather for the use of gasoline.

The good results in the first three months of 1940 reflected record-breaking sales of heating oil and somewhat improved gasoline prices.

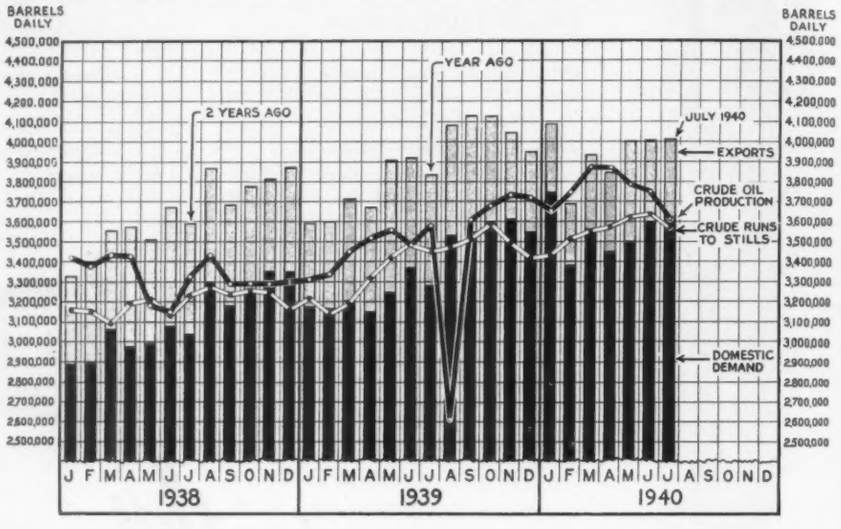
But, in the second quarter, heating oil business was waning seasonally, and gasoline prices continued the decline that got under way in the initial quarter. Consequently, the oil companies in the aggregate had less net income in April, May, and June than in January, February, and March.

For the latter half of 1940, moreover, earning power will be circumscribed by several unfavorable circumstances, especially the continued weak market for gasoline and the greatly curtailed volume of export business.

It is doubtful, in fact, if latter-half earnings will be as large this year as they were last year. For product prices improved materially late last summer and were comparatively good in the closing four months of the year, while they currently are down substantially from the levels that they reached late in 1940, with prices of gasoline, principal product of the industry, at the lowest level since the middle of 1933.

Furthermore, total volumes of

DEMAND FOR ALL U.S. OILS - CRUDE OIL PRODUCTION - REFINERY RUNS


BARRELS DAILY
2 YEARS AGO
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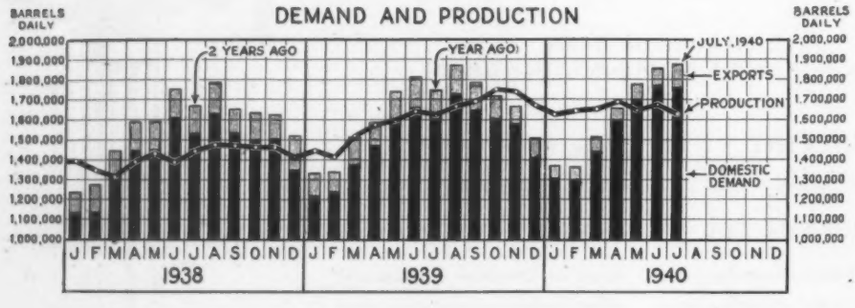
JULY 1940
EXPORTS
CRUDE OIL PRODUCTION
CRUDE RUNS TO STILLS
DOMESTIC DEMAND
J F M A M J J A S O N D J F M A M J J A S O N D J F M A M J J A S O N D
1938
1939
1940

Source: Bureau of Mines except data for June and July, 1940, which are estimates.

GASOLINE SITUATION

DEMAND AND PRODUCTION


BARRELS DAILY
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EXPORTS
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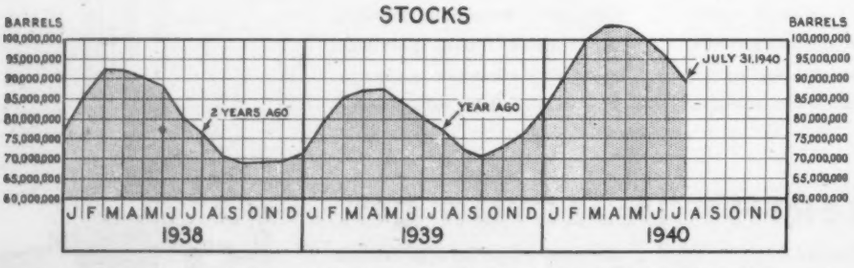
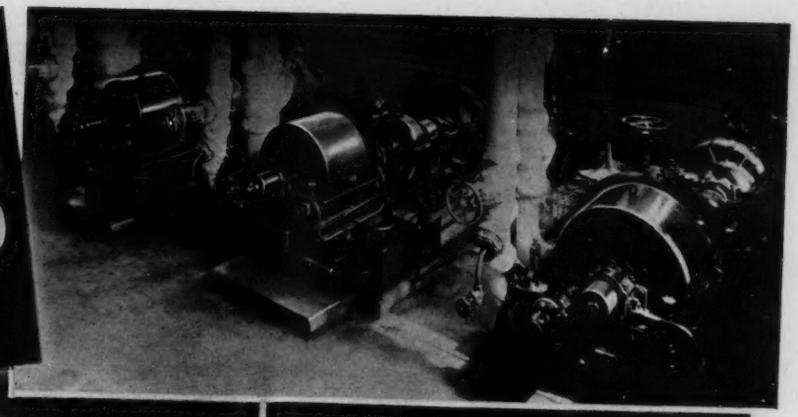
1938
1939
1940

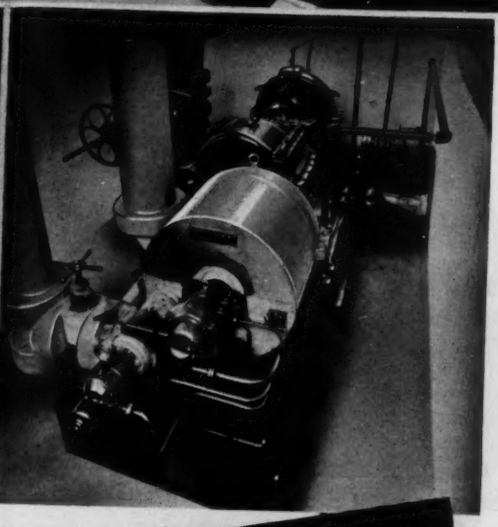
STOCKS

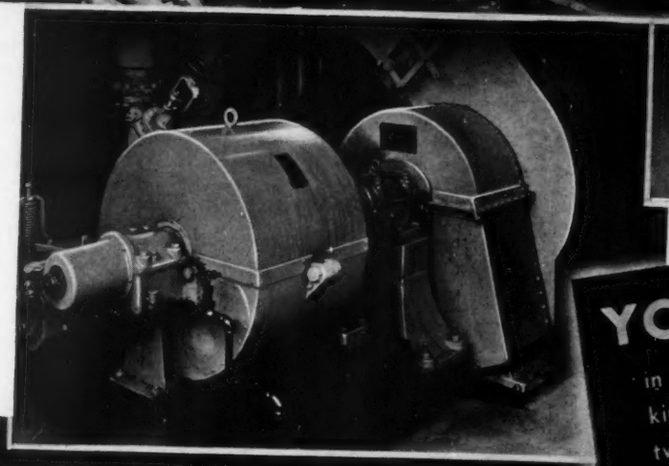


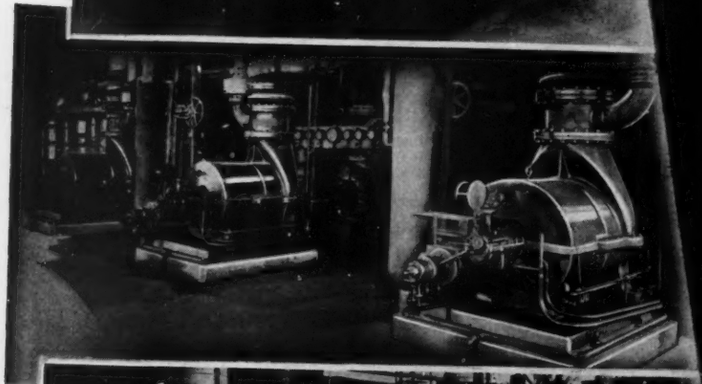
Source: Bureau of Mines except data for June and July, 1940, which are estimates.

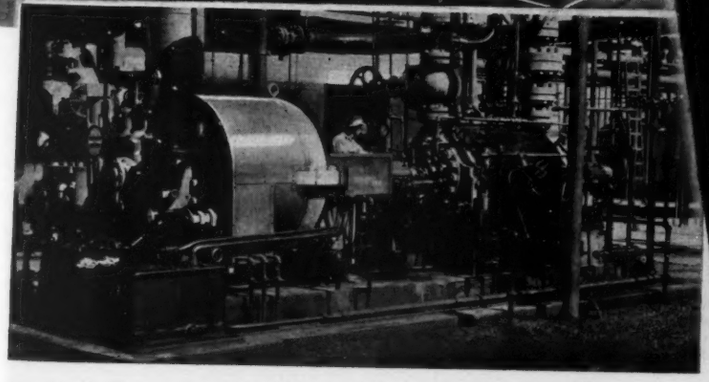
ELLIOTT TURBINES at work











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in refineries everywhere, indoors and out, on all kinds of drives, working on steam or gas, driving two or three pumps in tandem, driving through reduction gears, or driving direct. Varied service, but one high standard of turbine performance and dependability.

The Mechanical Drive Turbine Bulletins tell why refinery engineers favor these turbines. Write for them.

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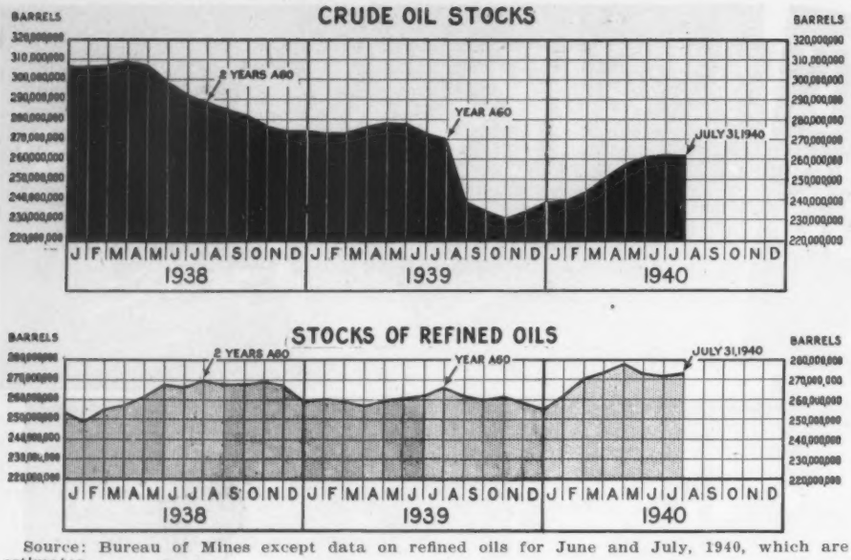
CRUDE OIL STOCKS
BARRELS
2 YEARS AGO
YEAR AGO
JULY 31, 1940
J F M A M J J A S O N D J F M A M J J A S O N D J F M A M J J A S O N D
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1938
1939
1940

Source: Bureau of Mines except data on refined oils for June and July, 1940, which are estimates.

business lately have not been much, if any, larger than a year ago, as gains in domestic sales have been largely offset by curtailment of exports.

In the latter half of 1940, therefore, the oil industry may not be able to equal its earnings record of the similar period of 1939, with its over-all volume of business little, if any, greater, and with prices of petroleum products lower.

The prospects would be improved, of course, if the national defense program should result in an extraordinary pick-up in domestic demand for oils in the closing months of this year, a possible development that offers the most promise among those now on the horizon.

However, it appears that orders and spending for national defense will not materially stimulate employment and business activity until October or November, at the earliest; and it is doubtful, therefore, if any sharp increase in petroleum consumption will occur before the end of this year.

The industry is generally reconciled to the probability that volumes of export business will continue greatly curtailed in the latter half of 1940, and it is anticipated that shipments abroad may be even lower in 1941. The export outlook is distinctly unfavorable regardless of further developments in the Eu-

Changes From Year Ago in Stocks of Crude and Refined Oils in the United States

(Figures indicate barrels)

LATEST WEEKLY DATA

(Sources: Crude stocks, Bureau of Mines; all other figures American Petroleum Institute.)

STOCKS OF:	July 27 1939	July 27 1940	Percent Change
Gasoline	78,158,000	90,173,000	+15.4
Gas Oil & Distillate	34,893,000	38,981,000	+11.7
Residual Fuel Oil	115,162,000	105,924,000	— 8.0
Crude Oil	268,513,000	262,579,000	— 2.2

LATEST MONTHLY DATA

(Source: Bureau of Mines.)

ITEM	STOCKS AT END OF MAY 1939	1940	Percent Change
SUMMARY—			
Crude Petroleum:			
Refinable in U. S.	278,087,000	261,839,000	— 5.8
Heavy in California	14,492,000	13,265,000	— 8.5
Natural Gasoline	6,212,000	6,514,000	+ 4.9
Refined Products	270,177,000	282,176,000	+ 4.4
Total, all oils	568,968,000	563,794,000	— 0.9
Day's supply:			
May Basis	147	144	— 2.0
5 Months Basis	153	145	— 5.2
PRODUCTS—			
Gasoline:			
Finished	78,342,000	93,474,000	+19.3
Unfinished	5,858,000	7,385,000	+26.1
Total	84,200,000	100,859,000	+19.8
Aviation Gasoline (Included above)	.....	3,942,000	.....
Kerosene	6,551,000	5,309,000	—18.9
*Gas Oil & Distillate Fuels	22,088,000	23,112,000	+ 4.6
*Residual Fuel Oils	92,485,000	84,210,000	— 9.0
Lubricants	7,630,000	8,170,000	+ 7.1
Wax (pounds)	113,925,000	103,289,000	— 9.3
Coke (short tons)	716,000	681,000	— 4.9
Asphalt (short tons)	672,000	759,000	+12.9
Road Oil	1,219,000	1,360,000	+11.6
Miscellaneous	301,000	405,000	+34.6
Other Unfinished Oils	38,036,000	40,070,000	+ 5.4

* At refineries only.

Total Oil Demand Up in 1940 Despite Smaller Exports

Figures indicate barrels, and are from Bureau of Mines

	MAY 1939	MAY 1940	MAY Percent Change	FIRST FIVE MONTHS 1939	FIRST FIVE MONTHS 1940	FIRST FIVE MONTHS Percent Change
SUMMARY						
Total Demand	120,382,000	121,190,000	+ 0.7	560,619,000	592,314,000	+ 5.7
Daily average	3,833,000	3,909,000	+ 0.7	3,713,000	3,897,000	+ 5.0
Exports:						
Crude petroleum	8,643,000	4,886,000	— 43.5	29,118,000	20,723,000	— 28.8
Refined products	12,128,000	7,541,000*	— 37.8	48,049,000	35,200,000	— 26.8
Total exports	20,771,000	12,427,000	— 40.2	77,167,000	55,923,000	— 27.6
Domestic Demand:						
Total domestic demand	99,611,000	108,763,000	+ 9.2	483,452,000	536,391,000	+ 11.0
Daily average	3,213,000	3,508,000	+ 9.2	3,202,000	3,529,000	+ 10.2
TOTAL DEMAND FOR PRODUCTS						
Motor Fuel:						
Domestic	49,547,000	52,946,000	+ 6.9	208,406,000	223,163,000	+ 7.1
Exports	4,390,000	1,992,000†	— 54.6	18,936,000	10,509,000	— 44.5
Total	53,937,000	54,938,000	+ 1.8	227,342,000	233,672,000	+ 2.8
Aviation Gasoline: (included above):						
Domestic	‡	455,000	.....	‡	2,001,000	.....
Export	691,000	415,000	— 40.0	2,141,000	1,246,000	— 41.8
Total	.....	870,000	.....	.....	3,247,000	.....
Kerosene:						
Domestic	4,368,000	5,297,000	+ 21.2	26,492,000	31,096,000	+ 17.4
Exports	653,000	386,000	— 40.9	3,254,000	1,959,000	— 39.8
Total	5,021,000	5,683,000	+ 13.2	29,746,000	33,055,000	+ 11.1
Gas Oils & Distillate Fuels:						
Domestic	7,523,000	10,059,000	+ 33.7	64,032,000	79,480,000	+ 24.1
Export	4,004,000	2,130,000	— 46.8	13,079,000	9,197,000	— 29.8
Total	11,527,000	12,189,000	+ 5.7	77,111,000	88,677,000	+ 15.0
Residual Fuel Oils:						
Domestic	25,047,000	26,017,000	+ 3.9	131,987,000	142,388,000	+ 7.9
Export	1,854,000	1,379,000	— 25.6	7,693,000	5,751,000	— 25.2
Total	26,901,000	27,396,000	+ 1.8	139,680,000	148,139,000	+ 6.1
Lubricants:						
Domestic	2,132,000	2,063,000	— 3.2	9,151,000	9,660,000	+ 5.6
Exports	981,000	1,173,000	+ 19.6	4,157,000	5,684,000	+ 36.7
Total	3,113,000	3,236,000	+ 4.0	13,308,000	15,344,000	+ 15.3
Wax (pounds):						
Domestic	28,533,000	24,103,000	— 15.5	111,433,000	125,198,000	+ 12.4
Export	16,045,000	22,404,000	+ 39.6	100,024,000	116,611,000	+ 16.6
Total	44,578,000	46,507,000	+ 4.3	211,457,000	241,809,000	+ 14.4
Coke (short tons):						
Domestic	117,400	111,400	— 5.1	552,600	567,500	+ 2.7
Export	32,800	23,000	— 29.9	84,300	86,300	+ 2.4
Total	150,200	134,400	— 10.5	636,900	653,800	+ 2.7
Asphalt (short tons):						
Domestic	493,400	466,000	— 5.6	1,403,100	1,315,000	— 6.3
Exports	2,900	30,800	.....	20,200	122,500	.....
Total	496,300	496,800	+ 0.1	1,423,300	1,437,500	+ 1.0
Road Oil:						
Domestic	695,000	611,000	— 12.1	1,543,000	1,112,000	— 27.9
Miscellaneous:						
Domestic	214,000	139,000	— 35.0	908,000	693,000	— 23.7
Exports	9,000	117,000	+1200.0	40,000	579,000	+1348.0
Total	223,000	256,000	+ 14.8	948,000	1,272,000	+ 34.2

* Exclusive of 14,000 barrels exported from non-contiguous territories but inclusive of 638,000 barrels shipped from U. S. to territories. † Includes benzol, 30,000 barrels in May, 1940. ‡ Not available.

12 MONTHS WITHOUT REPACKING HANDLING 89% SULFURIC . . .

"K" Monel 1½" dia. pump shaft after 12 months' use in prominent Texas refinery handling 89% sulfuric acid. The shaft was removed for inspection only.

Outstanding record in prominent refinery made by "K" Monel pump shaft

In the gasoline treating plant of a big refinery in Texas, constant trouble was experienced with packing in pumps. Operating 3 hours a day, these pumps handled 2000 gallons of 89% sulfuric acid. The shafts causing the trouble were made of carbon steel and needed replacement approximately every 6 months.

Shafts of a corrosive resistant metal were tried, with even worse results. They gave out in 6 weeks.

Then this user put in shafts of "K" Monel. Result: *In over 12 months pumps have not once been repacked...and inspection shows the shafts are still in excellent condition.*

Through heat treatment, the Nickel-base alloy "K" Monel develops strength and hardness comparable to heat treated alloy steel. In ability to resist combined corrosion and wear this alloy probably excels any other commercially available metal.

Write for further information on this and other long-life refinery metals. Ask for bulletins C-2, "Monel and Nickel in Oil Refineries," and T-9, "Engineering Properties of 'K' Monel." Address:

THE INTERNATIONAL NICKEL COMPANY, INC.
67 Wall Street New York, N. Y.

"K" MONEL

"K" Monel is a registered trademark of The International Nickel Company, Inc., which is applied to a nickel alloy containing approximately two-thirds nickel and one-third copper, with a small aluminum content that permits hardening by heat treatment.

Oil Exports Down Sharply in First Nine Months of War

Figures indicate barrels, except as otherwise noted, and are from Bureau of Mines

ITEM	NINE MONTHS PERIOD			MONTH OF MAY		
	Ended May 31, 1939	Ended May 31, 1940	Percent Change	1939	1940	Percent Change
Crude Oil	51,960,000	44,578,000	— 14.2	8,643,000	4,886,000	— 43.5
Products:						
Motor fuel	36,111,000	23,880,000	— 33.9	4,390,000	[6]1,992,000	— 54.6
Aviation gasoline (included above)	[1]2,141,000	[2]2,179,000	+ 1.8	691,000	415,000	— 40.0
Kerosene	5,882,000	4,662,000	— 20.8	653,000	386,000	— 40.8
Gas oil and distillate	21,764,000	19,082,000	— 12.3	4,004,000	2,130,000	— 46.4
Residual fuel oil	14,023,000	11,107,000	— 20.8	1,854,000	1,379,000	— 25.6
Lubricants	7,099,000	10,181,000	+ 43.4	981,000	1,173,000	+ 19.6
Wax (pounds)	184,946,000	192,989,000	+ 4.3	16,045,000	22,404,000	+ 39.6
Coke (short tons)	158,900	184,200	+ 15.9	32,800	23,000	— 29.9
Asphalt (short tons)	38,300	[3]435,000	.....	2,900	30,800	.....
Miscellaneous	79,000	642,000	+ 713.0	9,000	117,000	+1200.0
[4]Total Refined Products	85,645,000	71,682,000	— 16.3	12,128,000	[5]7,541,000	— 37.8
Total Crude & Products	137,605,000	116,260,000	— 15.5	20,771,000	12,427,000	— 40.2

[1] September, October, November, 1938, not included. [2] September, 1939, not included. [3] Beginning January, 1940, includes both manufactured and unmanufactured asphalt; only unmanufactured asphalt being previously shown. [4] Not the sum of the above figures, some of which do not indicate barrels. [5] Exclusive of 14,000 barrels exported from non-contiguous territories, but inclusive of 638,000 barrels shipped from U. S. to territories. [6] Includes benzol, 30,000 barrels in May, 1940.

ropean war, and defeat of Great Britain would be only another blow in a beating for the oil industry of the United States.

The outlook for the gasoline market, likewise, is not very promising, at best. For the surplus of that product currently on hand is so large as virtually to preclude any marked improvement in prices at least until next spring.

Rates of withdrawal from gasoline storage in recent weeks have indicated that the industry is likely to have on hand around 80,000,000 barrels of gasoline on September 30, at the beginning of the fall-winter period of curtailed consumption, when seasonal accumulation of stocks occurs.

Such a quantity would be about 15,000,000 barrels in excess of actually needed stocks as of September 30, for economists regard about 65,000,000 barrels as sufficient at that time.

Even if the inventory were cut down by September 30 to 75,000,000 barrels, an achievement that would require average withdrawals of 1,600,000 barrels weekly between now and then, the stocks still would be 10,000,000 barrels above the indicated minimum requirements. And such a surplus would be a serious handicap, which would make extremely difficult the holding down of the gasoline inventory to a satisfactory level as of March 31 next year.

Not yet within sight, therefore, is any noteworthy improvement in the gasoline market, and for the rest of this year and the early part of next year the outlook is uninspiring.

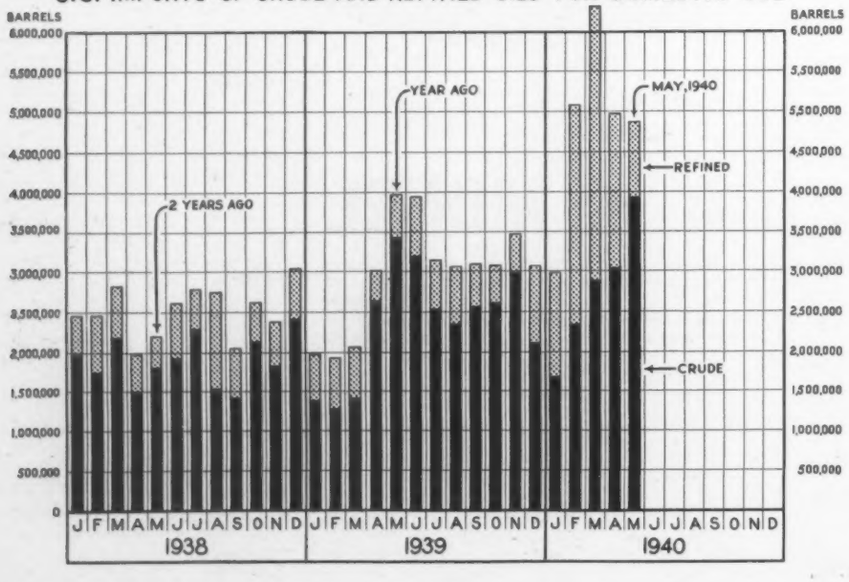
Currently, gasoline stocks are about 12,000,000 barrels higher than a year ago, and the gain largely represents surplus gasoline. For the stocks of a year ago were quite adequate for meeting market requirements, and total demand currently is only a little greater than last year, as the increase in domestic consumption has been offset to a considerable extent by the decline in exports.

The industry could reduce the excess of gasoline in storage by cutting down the yield of that product and raising the yield of light fuel oil; and such action also would tend to hold down next fall and winter the forced production of gasoline in conjunction with the turning out of seasonally large quantities of heating oil. However, there has not been, so far, much effort to turn the yields of gasoline and light fuel oil to advantage, despite considerable publicity on the subject.

While gasoline prices are extremely low, the markets for most of the other refined products are relatively good, despite some marking down of prices in the past several months.

The crude oil markets, similarly, are steady, and the recent threat of a general crude cut in the Mid-Continent has been virtually eliminated.

U.S. IMPORTS OF CRUDE AND REFINED OILS FOR DOMESTIC USE



Source of data: Bureau of Mines.

Oil Imports for Domestic Use Up Sharply

Figures indicate barrels and are from Bureau of Mines.

MONTH	Crude Oil	Refined Products	Total
January:			
Jan., 1939	1,373,000	609,000	1,982,000
Jan., 1940	1,664,000	1,321,000	2,985,000
Percent Change	+21.2	+117.1	+52.0
February:			
Feb., 1939	1,266,000	654,000	1,920,000
Feb., 1940	2,343,000	2,731,000	5,074,000
Percent Change	+85.0	+320.0	+164.0
March:			
Mar., 1939	1,404,000	659,000	2,063,000
Mar., 1940	2,895,000	3,410,000	6,305,000
Percent Change	+106.2	+417.4	+205.6
April:			
April, 1939	2,648,000	366,000	3,014,000
April, 1940	3,041,000	1,948,000	4,989,000
Percent Change	+14.8	+432.0	+65.5
May:			
May, 1939	3,434,000	529,000	3,963,000
May, 1940	3,921,000	934,000	4,855,000
Percent Change	+14.2	+76.5	+22.5
1st 5 Months:			
1939	10,125,000	2,690,000	12,815,000
1940	13,864,000	10,344,000	24,208,000
Percent Change	+36.9	+284.4	+88.9

The Look Box

Aviation Gasoline Under Embargo

In a surprise move, following the placing of aviation gasoline and fuel oil exports under export license control, President Roosevelt on July 31 placed a flat embargo on all exports of aviation gasoline to any nations except those of the Western Hemisphere.

The only exception provided was in the case of American-owned aviation companies operating outside the Americas, which are still to be able to secure such fuel as they may need for their operations.

Department of Commerce statistics indicated that England would be the principal sufferer under the embargo, that country taking 504,196 barrels of the 1,164,343 barrels of aviation gasoline shipped abroad during the first half of this year. France was an even heavier purchaser, taking 513,513 barrels during the period, but passed out of the picture as a market when the country capitulated to Germany. Other European shipments, now also cut off because the countries are largely in the hands of or controlled by Germany, were 32,470 barrels to Sweden, 7890 barrels to Finland, 6867 barrels to Norway, 6857 barrels to the Netherlands, 3275 barrels to the Azores, 2727 barrels to Portugal and 898 barrels to Spain.

The department's records show no shipments to Germany, Italy, Japan or Russia, against the last two of which the State Department instituted a "moral embargo" last year.

The announcement of the embargo, made by Stephen Early, presidential secretary, was that Col. R. L. Maxwell, administrator of export control, had recommended and President Roosevelt had approved the explanation that "in the interests of the national defense, the export of aviation gasoline is being limited to nations of the Western Hemisphere, except where such gasoline is required elsewhere for the operation of American-owned companies."

Four days prior to issuance of the embargo order, the President clarified his proclamation of July 23, placing petroleum and petroleum products under export license, so as to keep under control all supplies of aviation gasoline, aviation lubricating oil, crude oil suitable for aviation gasoline production and tetraethyl lead, but offering no impediment to sales abroad of other crude oils and refined products of which there are large above-ground stocks.

Under those regulations, issued last week, petroleum products subject to licensing were defined as "(a) aviation motor fuel, i.e., high-octane gasolines, hydrocarbons and hydrocarbon mixtures (including crude oils) boiling between 75 and 350° F. which with the addition of tetraethyl lead up to a total content of 3 cc. per gallon will exceed 87 octane number by the A.S.T.M. knock-test method; or any other material from which by commercial distillation there can be separated more than 3 percent of such gasoline, hydrocarbon or hydrocarbon mixtures; (b) aviation lubricating oil, i.e., any lubricating oil of 95 or more seconds Saybolt universal viscosity at 210° F. with a viscosity index of 85 or more.

"Tetraethyl lead—pure tetraethyl lead ethyl fluid or any mixture containing more than 3 cc. of tetraethyl lead per gallon."

To eliminate difficulties which the oil industry faced by reason of the sudden announcement of control, Acting Secretary of State Sumner Welles ordered application of the licensing requirements suspended until August 1, and instructed collectors of customs that cargoes loaded before the deadline would be granted clearance without export licenses.

While this order served to clear the way for tankers and cargo ships loaded with oil and scrap metal for Japan, which had been denied clearance papers following issuance of the president's announcement July 19, oil cargoes for Spain were indicated as not coming within the scope of the release order, since they were not held up by invoking control by earlier action of customs officers that checked their movement.

The order followed denial of clearance papers on two American tankers, which were due to leave Gulf ports for Spain early in July. This and other action came through activity of the Treasury Department and the Maritime Commission, had been active for six weeks previously in halting movement of American oil and gasoline to Spain and Japan in ships of American registry.

It was disclosed by Secretary of the Treasury Morgenthau that two tankers, destined for Santander and Balboa, Spain, with 200,000 barrels of American oil, were halted at Houston July 10 and 11 on orders from the Office of Merchant Ship Movements recently set up by the president, and denied clearance until they had unloaded their oil on shore.

At its regular meeting July 25, the commission disapproved a number of charters to aliens of vessels documented under the laws of the United States, including the following: Tanker D. G. Scofield, by Standard Oil Company of California, to Asano Bussan Company for one voyage with crude oil from California to Japan, loading on or about September 1 to 15, 1940; Tanker Elizabeth Kellogg, by Kellogg Steamship Corporation, New York, to Mitsubishi Shoji Kaisha, Ltd., for one voyage with crude oil, fuel oil, and/or Diesel oil from California to Japan loading about August 30; Tanker Torres, by Bernuth Lembcke Company, New York, to Mitsubishi Shoji Kaisha for one additional voyage from California to Japan with a cargo of petroleum commencing on or about July 28; Steamship Lewis Luckenbach, by Chilean Nitrate Sales Corporation, New York, to Mitsui & Company, for one voyage with a full cargo of gasoline in drums from a port or ports in the United States to Japan, commencing on or about July 29. Tankers Cities Service Missouri and Cities Service Kansas, by Cities Service Oil Company, New York, to Mitsui & Company for one voyage each with cargoes of gasoline from a United States Gulf port or ports to Japan, loading on or about July 23 and 28.

The commission approved the charter of the Tanker W. S. Miller by Standard Oil Company of California to Vessoyuznoe Obedinenie Soyuznfte-Export for one voyage with a cargo of gasoline from California to Vladivostok or Nagaevo, U. S. S. R., loading during the last half of July.

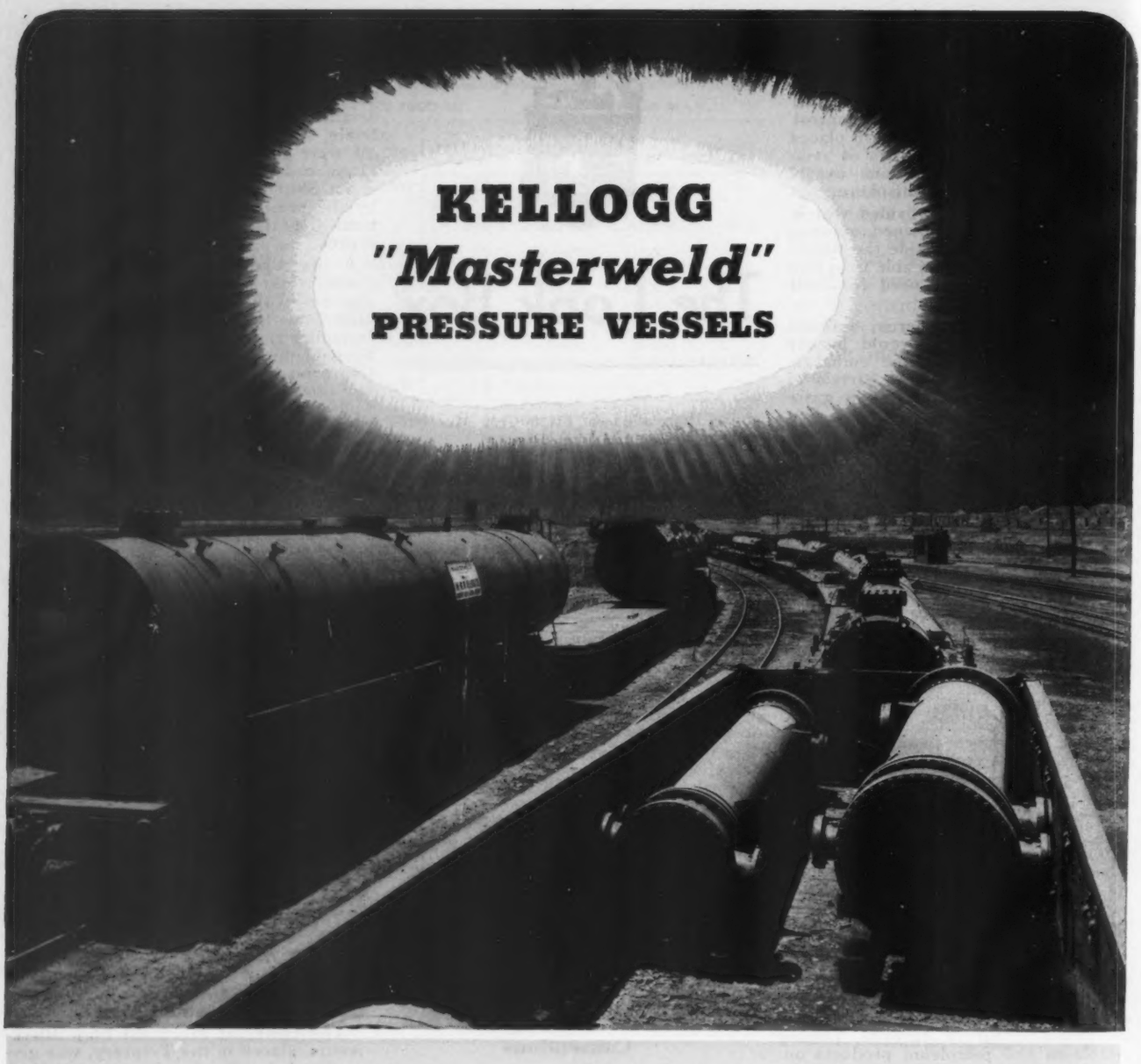
The Office of Merchant Ship Movements, placed in the Treasury, was given blanket authority to stop any ship, foreign or domestic, from entering or leaving an American port whenever the interests of the United States or the safety of the ship or cargo was believed to be in danger. The Neutrality Act, under which the areas from which American-flag ships are barred is specified by the president, covers practically all Europe with the exception of Spain and Portugal.

At the Maritime Commission it was learned that an application of Cities Service Oil Company for permission to charter two tankers, the Kansas and Missouri, to a Japanese company to carry gasoline to Japan, and an application of the Luckenbach Steamship Corporation to charter the Lewis Luckenbach to the same company to carry aviation gasoline in drums to Japan have been refused during the past week.

Texas circles stated that 300,000 barrels were involved in the Cities Service deal, and that the Japanese had placed inquiries for 1,000,000 barrels of aviation gasoline. The latter would represent nearly one fourth of the aviation gasoline in storage, and it was thought the government desired to keep such

Conventions

SEPT. 3– 5	American Society of Mechanical Engineers, Spokane, Washington.
9–13	American Chemical Society, Detroit, Michigan.
18–20	National Petroleum Association, Hotel Traymore, Atlantic City.
30	National Lubricating Grease Institute, Stevens Hotel, Chicago.
OCT. 4	Western Petroleum Refiners Association, Regional Meeting, Wichita, Kansas.
7–11	National Safety Congress and Exposition, Stevens Hotel, Chicago.
17–18	American Institute of Mining and Metallurgical Engineers, Petroleum Division, Los Angeles.
24–26	American Institute of Mining and Metallurgical Engineers, Petroleum Division, Tulsa.
25	Western Petroleum Refiners Association, Regional Meeting, Shreveport.
NOV. 1	California Natural Gasoline Association, Los Angeles.
11–15	American Petroleum Institute, Annual Meeting, Stevens Hotel, Chicago.
DEC.	Exposition of Chemical Industries, Grand Central Palace, New York.
2– 6	American Institute of Chemical Engineers, New Orleans.



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a large portion from going out of the country. In this connection, it was pointed out that at present the United States has the ability to produce 1,500,000 barrels of aviation gasoline monthly, although it has been making but about 1,000,000 barrels.

Maritime Commission officials said the charters were rejected as part of a rapidly developing policy of the commission to avoid allowing American ships in control of aliens to get "too far away" from this country. They revealed that within the past six weeks the commission has approved almost no charters outside the Western Hemisphere.

During the week ended June 5, it was disclosed, the commission canceled formerly approved charters of the same two Cities Service tankers and the Socony-Vacuum tanker Vacuum to Compania Arrendataria del Monopolio de Petroleos, S. A., of Madrid, to carry oil from Texas ports to Spain.

In informed circles outside the agencies directly concerned, it was said that the halting of shipments to Spain and Japan was directed against potential "go-betweens" for the axis powers or Japan. In the case of the tankers which were halted at Houston, it was said shipments to Spain have been much in excess of that country's normal requirements and the action was taken to prevent oil from reaching Germany and Italy through Spain.

It is generally understood that the British government some time ago called the attention of Washington to the fact that American oil shipments to Spain were really destined for Germany, and warned this government that it would find it necessary to seize such shipments as contraband. The situation was investigated by the State Department, which found that recent Spanish oil imports were considerably above normal consumption there.

This view was given partial confirmation by treasury officials, who explained that the refusal of clearance to the Aryan and Nevada was designed "to prevent an incident or a problem." These officials also cited reports they had received that the British government has extended its blockade to Spain and Portugal, saying that the tankers destined for Spain were held up because it was "safer for the preservation of American neutrality that they not be seized carrying contraband."

That the situation was well known in the Gulf area, it was said in Washington, was demonstrated by the fact that Jerry Sadler, member of the Texas Railroad Commission, some days ago came to Washington with the suggestion of an embargo on exports.

At the White House on July 26, President Roosevelt explained that his order placing oil under control was designed to conserve resources for national defense, particularly those of high-quality aviation gasoline.

Exporters of petroleum and other commodities placed under export control will be required to furnish full details of their proposed shipments, including the price and specific purpose for which the goods are to be used.

Regulations issued by the State Department require that an application be filed for each complete shipment to any one consignee; while one application may cover more than one commodity, it may not include shipments to more than one country.

A separate value must be given for each of the commodities intended to be shipped abroad, but such values may represent "the selling price only and should not include such supplementary costs as packing, freight, etc.," the department ordered.

Unsigned applications or applications which omit essential information called for will be returned. Any attempt to export a commodity different in any way from that licensed will be deemed a violation of the regulations, and violators will be subject to a fine of not more than $10,000 or imprisonment for not exceeding two years, or both.

Applicants for export licenses will be required to list the quantity of the commodity planned to be shipped and the approximate net value. They also will be required to state the specific purpose for which the material is required, and must state whether payment is made on delivery at the factory or at the port of exit and must give other essential terms of the sales contract.

Not only the name and address of the consignor is required, but also his nationality. The same requirement covers the seller in the United States, who also must give the nature of his business.

Exporters were warned by the department that applications for licenses must contain adequate descriptions of articles and materials to be exported. If an application fails adequately to describe the shipment, it will be returned for completion.

The country designated on applications as the country of destination must in all cases be the country of "ultimate destination," the regulations provide. If goods exported are consigned to one country with the intention that they be trans-shipped to another country, the latter must be named as the country of destination.

Exports licenses will not be transferable and will be subject to revocation without notice. If not revoked they are valid for one year from the date of issuance. The law, as now written, will apply for two years, expiring on June 30, 1942, unless extended by Congress.

Although restrictions were being invoked prior to issuing the licensing order, movement of petroleum products through export channels in June was close to the total for the corresponding month of 1939. Department of Commerce figures indicate that 5,692,000 barrels of crude oil were exported in June, 1940, against 5,831,000 barrels in June, 1939, bringing shipments for the first half of this year to 26,478,000 barrels, valued at $35,138,000, while the total for the first half of 1939 was 34,949,000 barrels, valued at $45,198,000.

Motor fuel exports for the half year, 1940 were 10,306,000 barrels, valued at $34,599,000, against 18,787,000 barrels, valued at $46,266,000 for the first half of 1939.

Lubricating oil exports for the first six months of 1940 were 1,065,000 barrels, valued at $8,611,000, while the figures for the corresponding period of 1939 were 1,093,000 barrels and $7,094,000.

Lubricating oil exports ran well ahead in the first six months of 1940, in comparison with 1939. The 1940 totals were 6,694,000 barrels, valued at $60,481,000, while the 1939 totals were 5,215,000 barrels, valued at $36,398,000.

Delay Sought in Anti Trust Cases

Opposition of the National Defense Advisory Commission to any action which would disturb major industries necessary to the defense program this week halted the filing of new anti-trust proceedings against the oil industry by the Department of Justice.

Prepared to go ahead with cases which have been developed over a period of many months and for which the Supreme Court decision in the Madison case was seen as flashing a green light, Assistant Attorney General Thurman Arnold, planning the most comprehensive prosecution yet undertaken, involving the industry from top to bottom, found a last-minute barrier in the realistic attitude of the defense commission.

That body held that to upset the industry now might endanger the government's effort to enlist the cooperation of oil companies in the construction of plants for the manufacture of toluol and high-octane aviation gasoline.

Grave fears were expressed that if the department went ahead with its plans the industry might be afraid to undertake any further expansion at this time, since the large companies upon which the government would rely for the greatest effort, which would necessitate large expenditures, would be the major objects of attack.

Officials of the anti-trust division see in the advisory commission's opposition a threat to the whole Administration monopoly drive, initiated in 1937, of which the oil, motion picture and construction industries have been the most heavily attacked groups.

The controversy between the department and the commission is only one of several which are interfering with the smooth progress of the defense program. Another difference of opinion exists between the commission and the Army and Navy Munitions Boards over the proper procedure for the letting of contracts, the War and Navy departments being unwilling to abandon the system of asking for bids and awarding contracts to the lowest bidder in preference of the commission-advocated private negotiation of contracts which will enable the government to decentralize war production.

Under the commission plan, it will be possible to establish defense industries at interior points, where they will be safer from aggression. Under the bid method, it is claimed, most of the business goes to the industrial East, where plants are susceptible to raids from the sea.

It is understood that when the defense commission began its effort to enlist industry in the defense drive, an agreement was reached with Assistant Attorney General Arnold that no cases would be brought against any industrial combination essential to the national defense. The agreement, however, was to be limited to specified defense work and the anti-trust division was to remain free to prosecute restraints of trade or price fixing in activities not connected with the national defense.

The controversy over the oil prosecutions, however, indicates that members of the commission do not believe that the agreement was sufficiently comprehensive and hold the view that

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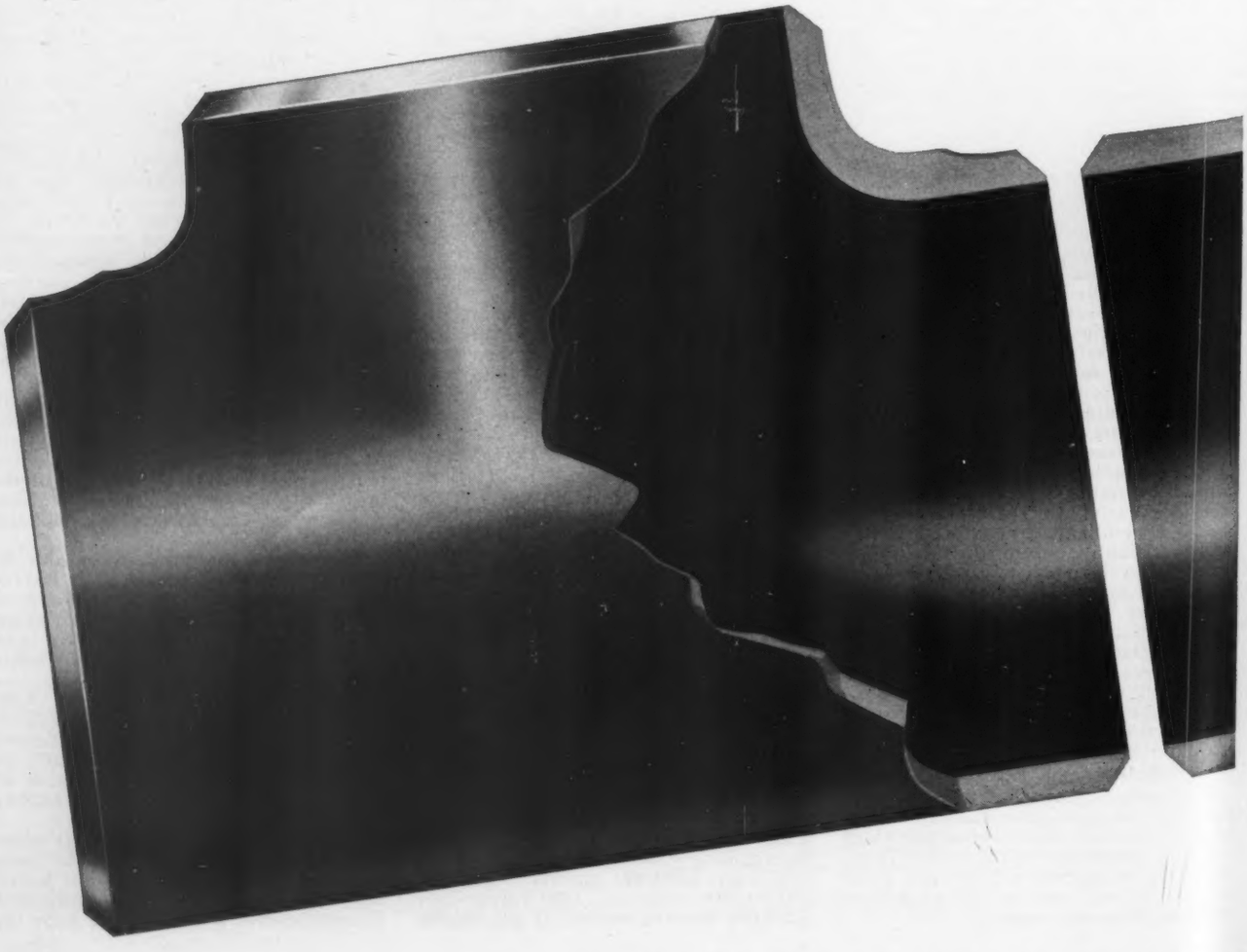

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no "all industry" cases should be brought at the present time.

While definite information as to the exchange between the commission and the department is lacking, it is understood that the commission did not suggest that the Justice Department abandon its enforcement of the anti-trust laws permanently, but rather that the oil proceedings be delayed.

With matters at a stalemate, the question was referred to Attorney General Robert Jackson, who explained that the defense commission would make a further study of the proposed suit and its possible effects on the defense program.

While the Department of Justice has revealed no details of its proposed move against the oil industry, it is understood an action would be filed in the District of Columbia court, naming 22 major companies and about 300 subsidiaries and affiliates. The case has been in preparation for many months.

In a formal statement in explanation of the situation, Attorney General Jackson on July 31 said that the anti-trust division had recommended the filing of a civil suit against the companies, comprising a large part of the domestic industry, "to force these companies to divest themselves of certain types of properties, such as pipe lines and tankers and marketing facilities, and to disintegrate companies so as to separate transportation and marketing from the production of oil."

At the same time, he said, realizing that the supply and transportation of oil now have relation to the national defense, Assistant Attorney General Arnold recommended that the matter of commencement of the action be taken up with the National Defense Advisory Commission to ascertain its opinion as to the effect on the national defense program.

"The action has been the result of a long history of litigation, the relief demanded is extensive, and the bill of complaint is lengthy," Mr. Jackson explained. "The commission has requested time to inform itself as to the effect of this action on the national defense interest before furnishing the Department of Justice its views. This request of the commission for time to inform themselves before giving their approval to this action was obviously reasonable and has been granted. In addition to the complex nature of the action itself, I am informed that there are specific problems relating to pipe line transportation, the manufacture of synthetic rubber and other matters in which the commission may find that defense requirements can be met only by the investment of additional sums in properties as to which this action seeks divestiture.

"The commission did not want to render a snap judgment, nor did I want a snap judgment from the commission. Specific problems may need additional information from this department as to the effects of this action and as to how the specific problems could be handled."

The Attorney General disclosed that he had conferred with members of the commission, whose only request is for time to consider the matter.

"It has not sought nor suggested the abandonment of the action in this or any other case," he asserted. "Its opinion has not been and would not be sought in any case that did not appear to affect national defense. No decision will be made as to whether this action will be authorized until the commission is in a position to report its effects on the national defense."

A statement in similar vein was issued by the National Defense Advisory Commission, in which it was pointed out that "it was apparent, on its face, that this suit, if successful, would require substantial changes in the entire economic set-up of an industry considered basic to the national defense."

Neither the commission nor any of its members, the statement declared, has "made any request of the Attorney General except for time necessary to consider the effect of the proposed action and, of course, no requests will be made until the detailed opinion is complete."

Reid Joins Staff of Oklahoma University

Laurence S. Reid, who has been development engineer for Black, Sivalls & Bryson, Oklahoma City, has been appointed associate professor of the school of chemical engineering, University of Oklahoma, Norman. The move takes Reid back to the institution from which he obtained his master's degree in 1937.

His undergraduate work was at Rice Institute, Houston, and Iowa State College, where he received the degree of bachelor of science in 1931. From 1931 until 1936 he was with Lion Oil Refining Company, Eldorado, Arkansas. Then followed work at the University of Oklahoma. Since then he has been with Phillips Petroleum Company in the research division and with Black, Sivalls & Bryson as development engineers.

His thesis at the University of Oklahoma dealt with the flow of oil and gas mixtures through porous media. The work was published by the American Institute of Mining & Metallurgical Engineers in 1938.

LAURENCE S. REID

Committee of Refinery Inspection Supervisors

Under the Division of Refining of the American Petroleum Institute a committee of refinery inspection supervisors has been named. One of its first activities will be preparation of a code of good practice for refinery inspection procedure.

F. L. Newcomb, Standard Oil Development Company, Elizabeth, New Jersey, has been selected chairman. R. P. Anderson of the A.P.I. staff is secretary.

Committee membership is: Fred Birley, Sun Oil Company, Philadelphia; F. B. Bluhm, Sinclair Refining Company, East Chicago, Indiana; W. L. Bowler, The Pure Oil Company, Chicago; F. C. Braun, Gulf Oil Corporation, Pittsburgh; R. S. Bridier, Bradford Oil Refining Company, Bradford; W. H. Creel, Phillips Petroleum Company, Bartlesville; J. K. Diechler, The Atlantic Refining Company, Philadelphia; G. C. Dick, Shell Oil Company, St. Louis; C. S. Dunham, Socony-Vacuum Oil Company, Philadelphia; M. B. Higgins, The Texas Company, New York; K. V. King, Standard Oil Company of California, San Francisco; L. D. Mann, Cities Service Oil Company, Bartlesville; W. M. Sims, Panhandle Refining Company, Wichita Falls; G. W. Watts, Standard Oil Company (Indiana), Chicago; H. F. West, Standard Oil Company of Ohio, Cleveland.

Illinois Crude Price Not Favorable to Skimming Plant

From an economic viewpoint the situation in the Illinois Basin has reached a stage where profitable operation of the skimming plant is doubtful. This has come about because of the willingness of buyers to pay the posted price, while current quotations on finished materials are not sufficient to leave a profit after paying for plant overhead and operating costs.

The area is producing large quantities of easily-refined crude oil, still the crude market has become consistently tighter, and there is a ready demand for every barrel of Illinois crude available. This demand is coming principally from companies whose pipe line facilities are sufficient to handle even a greater amount than is now being produced.

The price at this time is $1.05 per barrel and this price is being paid for practically all of the oil produced in the Basin. A limited amount of crude is moving at lower prices on contracts made some months ago, most of which have less than one to run to expiration. The low of the prices under these contracts is 90 cents, ranging up to a high of $1.00 per barrel. The greater part of new production is being run from Salem and Centralia fields, both of which are being produced with no restraint. Large quantities of the oil produced in these two pools are being recovered from the Devonian limestone, and the production curve is dropping rapidly as the formation pressure is relieved by the great qauntities of gas being burned at vent lines on the leases.

Nine Skimming Plants

Nine skimming plants have been built in the Illinois Basin to operate on new crudes. None of these has been built for

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New President C.N.G.A. Takes Over

P. S. Magruder (left), retiring president, handing gavel to L. V. Cassaday

permanent operation. Some were constructed of material moved into Illinois from East Texas, and one at Centralia has Scotch marine boilers for stills.

Three-combination topping and cracking plants have been built in Illinois wtih a total fresh crude charge of about 12,000 barrels per day. The straight skimming plants have a total through-put of around 30,000 barrels. The total cracking capacity of the three plants with such facilities is 6000 barrels per day with one building viscosity-breaking equipment.

A typical skimming plant operating on Illinois crude can show, on a charge of 1000 barrels of crude, a yeild as follows:

	Barrels
400 ep gasoline	330
500 ep kerosene	60
38° distillate	100
topped crude	500
gas and loss	10
Total	1000

If the plant is equipped with a single-coil furnace to crack the topped crude, the yield, from a charge of 500 barrels would be as follows:

	Barrels
400 ep gasoline	250
Tractor fuel	25
10/11° A.P.I., 250 vis fuel oil	190
gas and loss	35
Total	500

So, if the refiner had built a combination topping and cracking plant, the yield from 1000 barrels of fresh crude would be as follows:

	Barrels
400 ep gasoline	580
kerosene	60
distillate	100
tractor fuel	25
fuel oil	190
gas and loss	45
Total	1000

Refined products shipped into Illinois from Mid-Continent refineries are being retailed at prices, sometimes as low or lower than that obtanied at service stations at the gates of these same refineries. House-brand may be obtained as low as 16 cents per gallon, tax included, and independent service stations sell regular or Q gasoline as low as 13.4 cents per gallon, tax included. And the straight-run product, Illinois produced and that which is shipped in from elsewhere, is retailing at some stations, 8 gallons for $1.00, tax included. Therefore, if a refiner is operating a plant with skimming facilities only, he can easily calculate the price which he can obtain for the finished product. Deduct state and federal taxes of 5½ cents from the 12½ cents for white gasoline, there would remain 7 cents, which would include profit, if any, to the retailer, transportation costs, and handling which would leave the refiner with a price of about 4 cents, for his gasoline at the loading rack.

It is the opinion in some quarters that the day of cheap crude in Illinois is past, and that from this point on, while there may be temporary recessions from the existing crude price, the general market will remain firm. It would therefore appear, from the standpoint of refinery economics, that the future of skimming plant operations in Illinois is none too bright.

Warren Petroleum Building Plant in Illinois

F. E. Thompson, who has been superintendent of the Fairbanks, Texas, gasoline plant of Warren Petroleum Corporation, has been transferred to Salem, Illinois, where the company is building a plant. This plant will handle 20,000,000 cubic feet of gas and is scheduled for operation by October 1.

Cassaday Heads California Natural Gasoline Association

L. V. Cassaday, general manager of Lomita Gasoline Company, assumed the office of president of the California Natural Gasoline Association, July 9, when directors, officials and committee chairman of the organization were guests of Lomite Gasoline Company at the Pacific Coast Club, Long Beach, California. A meeting of association directors followed the dinner.

P. S. Magruder, General Petroleum Corporation, retiring president, opened the meeting, then turned the office over to Cassaday.

Those attending the meeting were: P. S. Magruder, retiring president; L. V. Cassaday, president; W. C. Dayhuff, Standard Oil Company of California, vice president; G. L. Tyler, secretary-treasurer; J. H. Kinkel, chairman of the Publicity Commitee and the following directors:

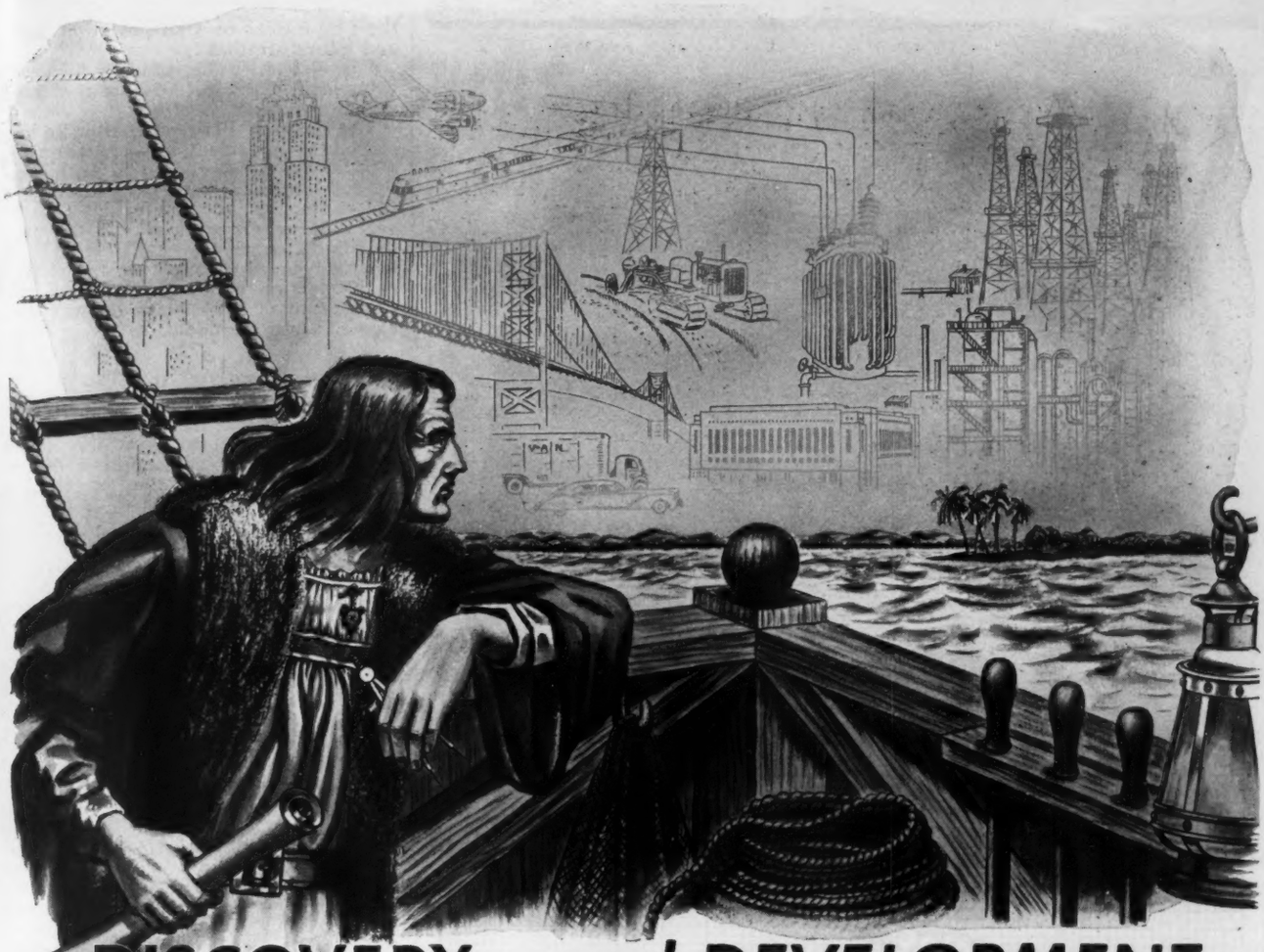
M. L. Arnold, Richfield Oil Corporation; J. C. Burks, O. C. Field Gasoline Corporation; F. J. Colton, Tidewater-Associated Oil Company; F. E. Davie, Shell Oil Company; O. C. Field, O. C. Field Gasoline Corporation; J. S. Fluor, Jr., The Fluor Corporation; R. D. Gibbs, Union Oil Company; C. D. Gard, Union Oil Company; Harry Fiske, The Cooper-Bessemer Corporation; R. W. Heath, Signal Oil & Gas Company; W. A. Kirk, California Southern Oil Company; W. H. Kraft, Honolulu Oil Corporation; F. A. E. Lowell, Del Rey Oil & Gas Company; H. R. Linhoff, Richfield Oil Corporation; G. C. McLaren, Standard Oil Company of California; H. M. Paulsen, Bankline-Norwalk Company; John Rogers, The Cooper-Bessemer Corporation; R. S. Tulin, Shell Oil Company; T. L. Taggart, Standard Oil Company of California, and R. C. Wheeler, General Petroleum Corporation.

Committee chairmen and others present were: C. S. Beard, chairman of the Taft chapter, C. C. M. O. Company; H. A. Leedy, chairman of the Entertainment Committee, Crane Company; M. W. Kibrie, chairman of the technical committee, General Petroleum Corporation; J. B. Taylor, chairman of the fall meeting commitee, Signal Oil & Gas Company, and L. C. Rawson, chairman of the auditing committee, The Texas Company.

Collier Elevated to Standard of California Presidency

H. D. Collier has been elected president of Standard Oil Company of California, following the death of W. H. Berg. Collier has been with the company since 1903, when he became a salesman in Seattle. He was senior vice president at the time of his election to the presidency.

After two years in Seattle he became a fuel oil salesman and spent most of his time introducing the use of fuel oil in the Pacific Northwest. In 1910 he was appointed assistant district sales manager in San Francisco and two years later became manager of that district. Two years later he was advanced to assistant manager of sales in the home office. He became manager of refined oil sales in 1919 and in 1922 he was appointed general manager of domestic, refined and lubricating oil sales. In this capacity he also served on



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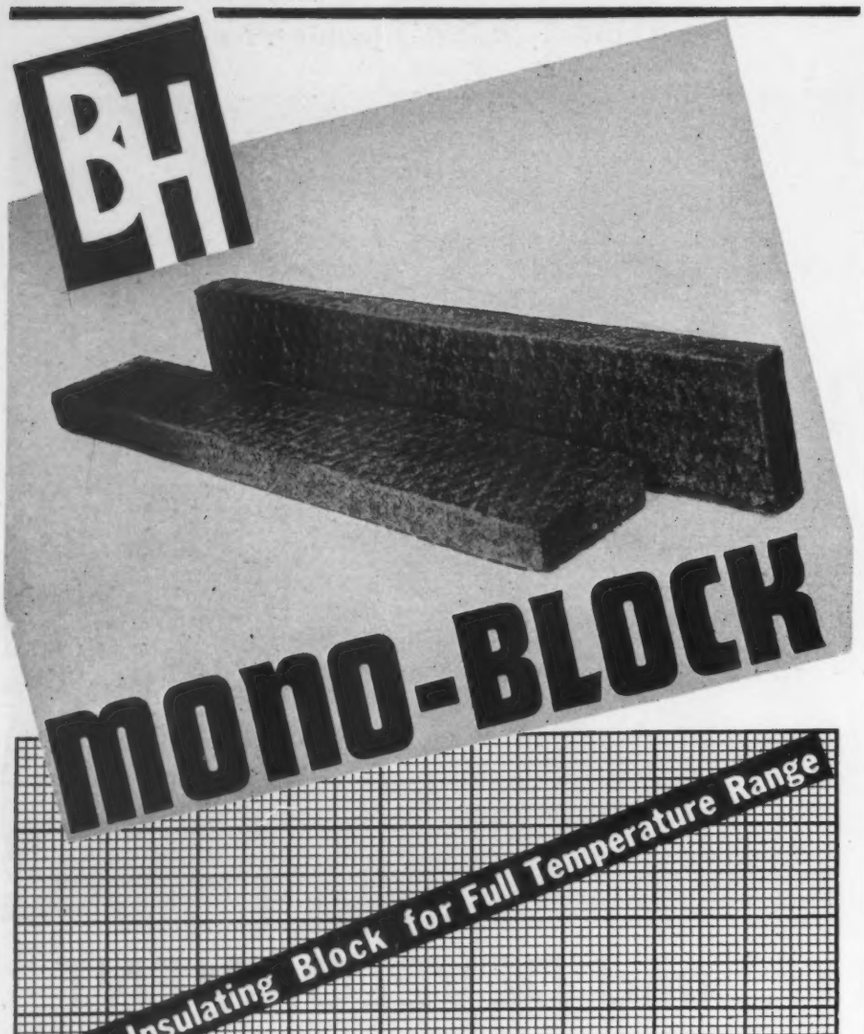

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the committees on transportation, sales and administration.

His election as a company director came in 1924 and in 1931 he was elected a vice president.

The death of Berg came after he had served as president since December, 1937, when he succeeded K. R. Kingsbury. Berg had been with Standard Oil Company of California for 38 years. His early work was in the production department.

He advanced through various phases of production and was elected to the directorate in 1924 when he was also elected a vice president.

Bureau Forecast of August Crude Oil Demand

Loss of export markets has offset gain in domestic consumption of petroleum products to the extent that the United States Bureau of Mines has forecast demand for domestic crude oil in August just 1 percent above the demand in July and only 15,400 barrels higher than actual demand for August, 1939. The explanation of the forecast follows:

"Daily average crude-oil production and runs to stills during the 5 weeks June 1 to July 6 were 3,744,000 and 3,622,000 barrels, respectively. During this period domestic crude stocks decreased an average of 18,000 barrels daily, indicating a demand of 3,762,000 barrels compared with the bureau's estimate of 3,620,000 barrels for June. Although the high runs are reflected in a desirable build-up of distillate fuel oil stocks amounting to about 4 million barrels in June, the reduction in gasoline stocks was about 750,000 barrels less than that estimated by the bureau.

"The European war has closed additional markets to exports of crude petroleum and refined products. The net effect of this decline in exports is to offset increases in the domestic market and to indicate a demand for domestic crude in August that is only slightly higher than for the same month last year. Liquidation of large stocks of gasoline accumulated during the winter months is proceeding slowly due to high runs to supply the relatively greater demand for light fuel oils and to build up depleted stocks of these oils. The general trend in domestic motor fuel consumption for the third quarter indicates an increase of at least 6.5 percent over last year. The percentage increase of refinery sales by months, however, may be very irregular. Anticipation of the increase in the federal gasoline tax may inflate the volume of sales in June and reduce them correspondingly in July. The trend of refinery operations indicates the continuance of relatively low gasoline yields and higher distillate yields until a better balance between stocks and demand is attained.

Motor Fuel

"Motor-fuel demand probably will not be comparable with actual consumption for the individual months of the summer of 1940. Anticipation of the ½-cent increase in the federal tax on gasoline, which was effective on July 1, probably resulted in large purchases of gasoline in June. The effect of this should be absorbed largely in reduced sales in July, although some of the effect may linger into August. The increase for August is estimated to be only about

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CHECK Its Features against Your Requirements *for:*

EASE OF INSTALLATION

Designed for wall or rack mounting. Needs only four bolts. The cast-iron head, a new feature, keeps the case away from the wall and enables you to make rigid conduit connections from top, bottom, or either side. Power and control terminals are clearly identified and accessible for making connections. Two stainless-steel tank holders provide a simple means for attaching tank.

LOW MAINTENANCE

All operating parts, including overload relays, are immersed in oil. Corrosive fumes cannot get at them. Cast-iron head, mentioned above, resists corrosive moisture that may condense on it. Case is copper-bearing steel painted with aluminum paint. Contactor is of husky construction and contacts are heavy copper.

EASE OF INSPECTION

The operating devices are easily accessible, particularly when the optional tank-lowering mechanism is used. This improved mechanism enables one man to lower and raise tank evenly and accurately with very little effort.

PROTECTION

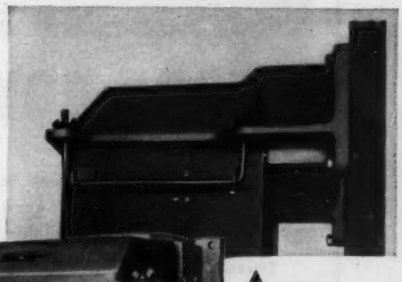
Thermal overload relays, specially designed for operation in oil, protect motor against damage from excessive overloads. They are mounted with contacts at bottom or side to prevent possibility of oil sludge interfering with their action. Undervoltage protection safeguards machines and operators from danger of unexpected restarting after a power interruption. Control and power wiring are widely separated and securely attached to provide maximum protection to operators.

FROM every angle—installation, inspection, maintenance, protection—this G-E oil-immersed starter is *the* motor control for high-voltage service in the corrosive atmospheres of refineries and chemical plants.

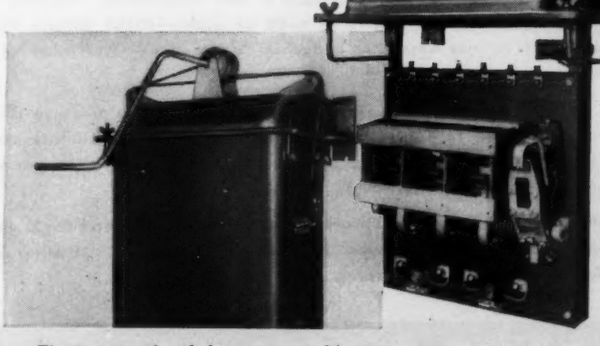
Developed to meet specific operating requirements, it is another example of how G-E engineers take the ideas and suggestions of users and incorporate them into improved products such as you expect of a progressive manufacturer.

As you consider its various features, remember that this starter is but one of a line of oil-immersed control that is as complete as you will find anywhere. General Electric is in a position to furnish low-voltage types, as well as high-voltage units with either high or moderate interrupting capacity. This control can also be furnished with contactor and terminals six inches under oil to make it suitable for installation in hazardous gas locations.

Our engineers will be glad to discuss your requirements with you and your contractor. Just get in touch with our nearest representative. General Electric, Schenectady, N. Y.



▲ The cast-iron head design enables you to wire from top, bottom, or either side



When in service, this operating mechanism is completely oil immersed

The improved tank-lowering mechanism facilitates inspection

GENERAL ELECTRIC

4½ percent over the abnormally high demand for August 1939, or 56,200,000 barrels.

"Forecasts by the principal exporters of motor fuel point to continued low shipments of motor fuel to foreign countries. The bureau estimates 1,900,000 barrels for August, which is 100,000 barrels less than the July estimate, and 2,308,000 barrels less than the actual exports in August 1939.

"Stocks of finished and unfinished gasoline on May 31 were 100,859,000 barrels. Statistics of the American Petroleum Institute indicate a decrease of 5,470,000 barrels during June, which would place the stocks at approximately 95,400,000 barrels on June 30. The bureau estimates a reduction of 6,400,000 barrels during August.

"Benzol and direct sales of natural gasoline are estimated as 1,200,000 barrels, making refinery production of gasoline 50,500,000 barrels. This is distributed among the various districts as follows (thousands of barrels): East Coast, 6690; Appalachian, 1870; Indiana-Illinois, 10,640; Oklahoma, 2920; Kansas, 2770; Texas Inland, 3610; Texas Gulf Coast, 11,960; Louisiana Gulf Coast, 1460; Inland Louisiana-Arkansas, 880; Rocky Mountain, 1380; California, 6320.

Crude Petroleum

"Natural gasoline to be blended at refineries is estimated as 6.2 percent of the total refinery gasoline production, or 3,130,00 barrels. The yield of straight-run and cracked gasoline, in order to provide for the demand for other oils, is estimated at 42.8 percent.

Estimated Daily Average Crude-Oil Demand by States (Barrels)

(As no changes in crude-oil stocks are involved in these estimates, they represent demand rather than production)

State	Forecast August 1940	Forecast July 1940	Actual August 1939
Texas	1,326,400	1,339,400	1,433,800
California	598,400	593,900	626,200
Illinois	440,600	402,300	283,400
Oklahoma	402,600	403,900	456,400
Louisiana	276,100	278,100	281,100
Kansas	166,800	159,400	131,200
New Mexico	105,200	106,100	99,600
Wyoming	81,300	80,600	79,100
Arkansas	65,200	67,400	59,900
Michigan	57,100	61,600	60,400
Pennsylvania	48,000	47,900	54,800
Montana	20,600	18,100	19,200
New York	14,000	14,000	16,800
Kentucky	13,900	14,200	18,300
Mississippi	10,300	9,700	.....
Indiana	10,000	9,000	4,400
West Virginia	9,000	10,000	9,100
Ohio	8,000	8,000	5,100
Colorado	4,200	4,800	3,500
	3,657,700	3,628,400	3,642,300

The application of this yield to the production of 47,370,00 barrels of gasoline gives crude runs of 110,690,000 barrels, or 3,570,600 barrels daily. Foreign crude runs are estimated at 3,300,000 barrels.

"Indications from the principal exporters point to continued curtailment in crude oil exports; the bureau estimates 3,700,000 barrels will be exported during August. This is the same as the July estimate, but 2,269,000 barrels less than the actual exports in August 1939.

"The estimate for crude oil to be used for fuel and losses for August is 2,300,000 barrels.

"The total demand for domestic crude oil in August, as indicated by the estimates above, is 113,390,000 barrels, or 3,657,700 barrels daily.

"The breakdown of the total estimated daily demand for domestic crude oil of 3,657,700 barrels gives the following crude requirements by states of origin. As these requirements may be supplied either from stocks or from new production, contemplated withdrawals from crude-oil stocks must be deducted from the bureau's estimate of demand to determine the amount of new crude required. These estimates are not recommendations for production but represent the projection of actual market trends by states.

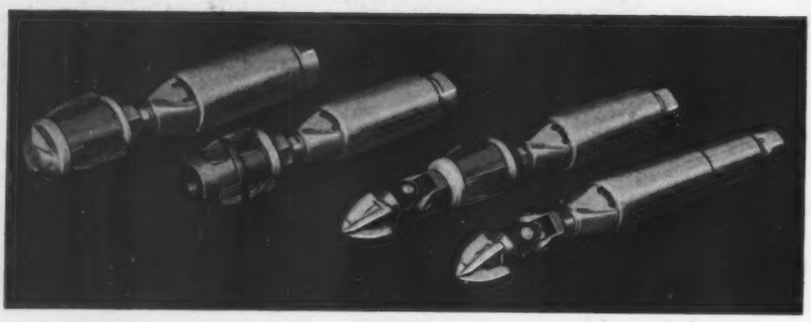
Federal Taxes Rise To $268,929,905

Federal oil and gasoline taxes returned a revenue of $268,929,905 during the fiscal year which ended June 30, last, an increase of $20,459,791 over the preceding year, it was disclosed last week by the Internal Revenue Bureau.

The bulk of this revenue was derived from the 1-cent-a-gallon tax on gasoline, which returned $226,186,669, an increase of $19,167,924 over the $207,018,745 reported for the fiscal year 1939, but the lubricating oil tax returned $31,232,589 compared with $30,496,636 in 1939, an increase of $735,953, and the tax on pipe-line transportation returned $11,510,646 compared with $10,954,732, an increase of $555,914.

Reflecting advance buying in anticipation of the 50 percent increase which went into effect July 1, June returns from the gasoline tax jumped to $21,085,903 from $18,958,336 the preceding month, the bureau reported. The

TUBE CLEANERS



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Wilson E P *(Extra Power)* Series Heavy Duty Air Motors deliver from 30% to 75% *more* power and use from 25% to 40% *less* air than ordinary tube cleaning motors of the same size.

Especially designed for the rapid, complete and economical removal of exceptionally hard or thick deposits of coke or scale—these motors do a better cleaning job in less time thus reducing "down-time" and labor costs to a minimum.

Wilson E P *(Extra Power)* Series Heavy Duty Air Motors, in sizes to clean tubes of from 1¾" I.D. to 6" I.D., are carried in stock for immediate shipment. The increased facilities of our new plant enable us to make prompt shipment of any larger sizes desired.

Write for the name of our representative nearest to you or send for a copy of our new thirty-six page catalog fully describing and illustrating the complete line of Wilson tube cleaning equipment.

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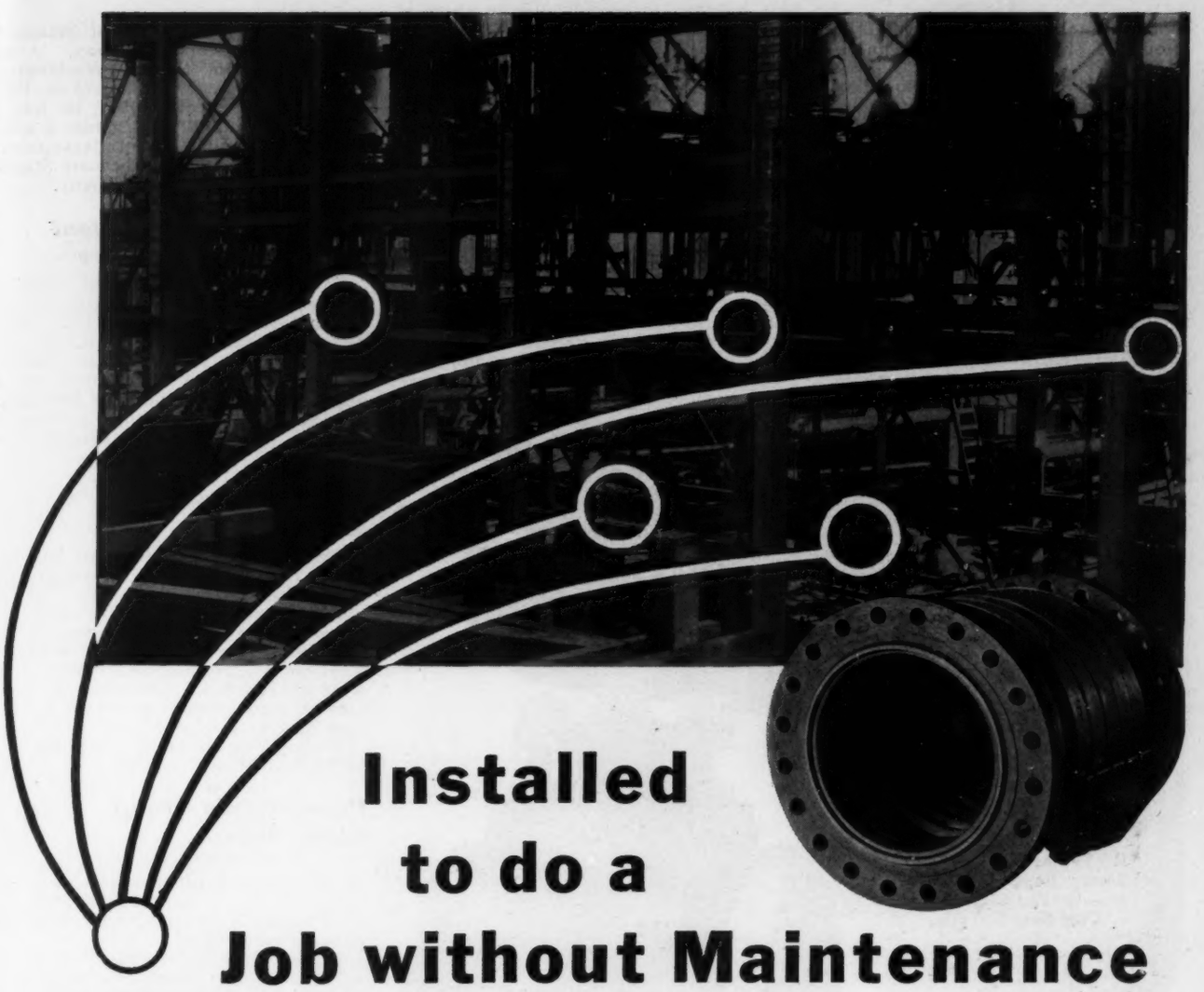

Installed to do a Job without Maintenance

BADGER
Stainless Steel
EXPANSION JOINTS

The picture above is that of a large refinery during construction. Note the expansion joints laid out on the floor ready for installation.

They're BADGER Stainless Steel Expansion Joints . . . and here are some of the values which the operator is going to get:

1 **joints that will withstand high temperatures.**

2 **joints that will function throughout their many years of life without maintenance; they're the packless type.**

3 **joints that, during their fabrication, were given the most modern, scientifically-controlled heat treatment.**

4 **joints that have the Directed Flexing design by which flexing stresses are definitely distributed.**

5 **joints that are made by the company who pioneered and developed the corrugated type of expansion joint.**

These values go with every BADGER Expansion Joint.

E. B. BADGER & SONS CO.

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month's total was more than $3,000,000 above the $17,796,086 collected in June, 1939.

The other two taxes also showed increases over May, lubricating oils returning $2,924,594 against $2,853,244, and pipe-line transportation $1,041,309 against $1,029,040. In June, 1939, these taxes returned $2,493,992 and $935,802, respectively.

For the first half of the current calendar year, collections from all three levies were well ahead of the corresponding period in 1939, bureau records showed. A total of $107,759,571 was collected from the gasoline tax, compared with $96,790,227; while lubricating oil paid $15,129,836 compared with $13,733,683, and pipe-line transportation $5,968,050 compared with $5,439,581.

F. A. Howard Becomes New Jersey Vice President

Frank A. Howard, president, Standard Oil Development Company, has been elected a vice president of Standard Oil Company (N. J.) with responsibility for all chemical, research and patent matters. His work will be that of coordinating the interests of the company in these fields.

In his new position he will retain places as official or director of the several companies engaged in these activities: Standard Alcohol Company, Standard I. G. Company, Jasco Incorporated, Hydro Patents Company, Ethyl Gasoline Corporation and others.

His work after joining the company in 1919 led to formation of Standard Oil Development Company. After graduation from George Washington University engineering school in 1911 and the law school in 1914, he joined the concern in 1919 to organize a general technical and patent department. In 1922 this department became Standard Oil Development Company.

Monrad Named Assistant to Defense Oil Adviser

C. C. Monrad, professor of chemical engineering, Carnegie Institute of Technology, Pittsburgh, has been named assistant to Dr. R. E. Wilson, oil advisor to the National Defense Advisory Commitee. Monrad is a graduate of the University of Michigan, who served for a time on the research staff of Standard Oil Company (Indiana).

Pennsylvania Grade Membership

Sinclair Refining Company has become a member of the Pennsylvania Grade Crude Oil Association. The application was approved by directors following the annual meeting. At the same time three new jobber memberships were approved; additional brands were approved for five present members and one renewal of license for the current year was approved.

The next board meeting will be held in September at Oil City.

Pennsylvania Group Elects Melvin

Parker L. Melvin, Bradford, has been elected president of Pennsylvania Grade Crude Oil Association. He succeeds W. F. Clinger of Warren, who held the position three years.

Other officials of the association are: A. E. Booth, Bradford, and Otto Walchli, Wellsville, New York, vice presidents; John A. Beck, Butler, recording secretary; Sam Messer, Oil City, treasurer; W. R. Reitz, Oil City, assistant treasurer; J. E. Moorhead, Oil City, executive secretary; S. F. Pratt, Oil City, assistant secretary; Fayette B. Dow, Washington, general counsel.

Camp Appointed on Two A.P.I. Committees

E. Q. Camp, Humble Oil & Refining Company, Baytown, Texas, has been appointed to the committee on corrosion of refinery equipment and to the committee on disposal of refinery wastes of the Refining Division of the American Petroleum Institute. His selection was to fill the place held by W. R. Hicks on the two committees.

Coastal Refiners Elect Officials

Officials of the Gulf Coast Refiners Association were elected at the annual meeting in Houston July 9: D. W. Hovey, Republic Oil Refining Company, president; G. L. Rowsey, Taylor Refining Company, and Cornelius Kroll, Southport Petroleum Company, vice presidents; L. F. Rothermel, Maritime Oil Company, treasurer; George Reid, executive secretary.

These officials are members of the board of directors, which also includes:

A Typical semi-steel 3-way flanged Homestead Plug Valve; "Cam-Seald" Type.

This massive Homestead Valve, that does the work of three ordinary valves, is typical of the full line of Homestead Valves engineered to give more efficient operation with lowest cost-per-year service. Whatever the Refinery application—from cracking still to loading rack—there is a Homestead Valve suited to the need. The advanced engineering features that enable 22 *Homesteads* to keep going strong after 10 years at 1100° F. in one installation, make them equally well adapted to the rigors of handling propane at 40 degrees below zero. Rugged construction, metals matched to service requirements, precision manufacturing, and 48 years of valve engineering experience make Homesteads "a Better Buy by the Year!" Specify them on your next order!

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Send for Valve Reference Book No. 38; and for special quantity prices on your valve requirements.

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A FURFURAL SOLVENT REFINING PLANT
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A BENZOL-KETONE DEWAXING UNIT
by LUMMUS

As part of an expansion program necessitated by the increasing demand for Continental's high quality lubricating oils, Lummus is designing and building a Lummus Furfural Solvent Refining Unit and a Lummus Benzol-Ketone Dewaxing Plant for the Ponca City refinery of Continental Oil Company. » » » We have some very interesting data on the economics of Furfural solvent refining and Benzol-Ketone dewaxing.

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John A. Bartlett, Amsco Refining Company; R. E. Holsten, Chamlette Petroleum Company; Ed Singer, Pontiac Refining Corporation; and S. S. Seltzer, Southwestern Oil & Refining Company.

Kennedy Manager of Atlantic Division

R. T. Kennedy has been selected manager of the Atlantic Division of Pennsylvania Refining Company, Butler, Pennsylvania. He will be located at 1 Gates Avenue, Jersey City, New Jersey.

The division includes a bulk storage department where equipment is maintained for the blending and packaging of products of the two refining plants at Karns City and Titusville.

Standard of New Jersey Announces Promotions

J. R. Carringer has been promoted to general manager of manufacturing operations for Standard Oil Company of New Jersey (Del.) to fill the post vacated by promotion of C. F. Smith who was named general manager. Carringer has been assistant general manager since 1933.

He has been connected with the refining industry since 1903 when he went to work in the tank car repair shop of Standard Oil Company (Indiana) at Whiting. Five years later he was transferred to the Wood River plant as assistant superintendent and in charge of experimental work. In 1918 he joined Standard Oil Company of New Jersey as assistant general manager of the Bayway plant. Three years later he became its general superintendent and in 1926 became refinery manager. He became assistant general manager of all refineries in 1933.

George H. Mettam has been appointed assistant general manager. His first work with the company was in 1910, after which he left and returned in 1913. By 1918 he was assistant mechanical superintendent of the Bayonne plant. In 1929 he was transferred to the manufacturing department as chairman of the mechanical superintendents' committee as well as staff engineer. He was named assistant manager at Bayonne in 1929 and promoted to manager in 1931. Two years later he was transferred to Bayway as local manager. Next he was made manager of process operations of the three plants and in 1936 he became manager of the New Jersey works.

H. G. Burks, Jr., has been promoted to assistant to the president. He came to the company in 1924 after graduation from Massachusetts Institute of Technology. In 1935 he became manager and technical advisor to the vice president in charge of manufacturing.

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THE BEST BURNERS

FOR THE TOUGHEST HEATING JOBS

★ REFINERY USE — short flames insure proper heat placement without tube loss.

★ GASOLINE PLANTS—either low pressure or high pressure type. Burns anything that can come through a gas line.

★ DRILLING BOILERS—gives complete satisfaction where drilling is the hardest: for example, John Zink Burners fire the barge boilers for deep sea drilling off the Gulf Coast.

JOHN ZINK COMPANY

Burners • Floor Furnaces • Unit Heaters

TULSA, OKLA. NEW YORK CITY

Service Awards

During 1940 1368 employes of Standard Oil Company (Indiana) will be given service pins in keeping with length of employment. In the list are 20 employes with 40 years of service, 82 with 30 years of service, 608 with 20 years of service and 658 with 10 years of service.

American Welding Society Convention at Cleveland

The annual meeting of the American Welding Society will be held in Cleveland, October 20 to 25, simultaneously with the National Metal Exposition. There will be 15 technical sessions, whose complete programs are being worked out.

Charles S. Smith To Socony-Vacuum

Following his resignation as vice president of National Refining Company, Cleveland, Charles S. Smith was named general sales manager of the White Star Division, Socony-Vacuum Oil Company, Detroit.

Power Exposition

Space registrations for the fourteenth National Exposition of Power and Mechanical Engineering indicate that the event will be the largest since 1930. The exposition will be held December 2 to 7 in the Grand Central Palace, New York. Nearly 250 exhibitors have taken space.

Attendance is limited by personal registration and is confined to executives, engineers and operating men who are interested in equipment for the generation, distribution and utilization of power. The affair is managed by International Exposition Company of which Charles F. Roth is president.

▼ PLANT ACTIVITIES ▼

Mississippi Plant: E. C. Johnston Refining Company is constructing a plant at Vicksburg, Mississippi, which will be operated by E. E. Peveto.

Polymerization at Los Alamitos: Pathfinder Petroleum Company, Los Angeles, has signed a license agreement with Universal Oil Products Company to install a catalytic polymerization unit to produce polymer gasoline from the cracked gases produced in its refinery at Los Alamitos. The unit will have a rated capacity of 345,000 feet of gas per day. H. A. Meek is president of the company, and Bert Devere is vice president and general manager.

Cracking at Huntington Beach: Socal Oil & Refining Company, Los Angeles, is modernizing the cracking unit in its refinery at Huntington Beach to operate the Dubbs process to increase the yield and improve octane rating of its gasoline. At present the refinery is running about 3000 barrels a day of Huntington Beach crude. When revamped, it will be a two-coil selective cracking unit with a capacity of 1150 barrels per day of 16.6 - gravity Huntington Beach topped crude. C. A. Johnson is president and general manager of the company, and J. H. Grimes is vice president and refinery superintendent.

Resume at Bradford: The plant of the Bradford Oil Refining Company, Bradford, Pennsylvania, was put back on stream in July after being shut down a month. First runs were around 100 barrels daily. Plant capacity is 2500 barrels.

New Pipe Line: Socony-Vacuum Oil Company has started construction on a pipe line from its Buffalo plant to Syracuse with a branch to Rochester. The gasoline carrier will be 6-inch.

Plant for Long Lake: Phoenix Refining Company, headed by Raymond Russell, San Antonio, has started construction of a 2000-barrel refinery in the Long Lake field.

Los Angeles 8000-Barrel Plant: Douglas Oil & Refining Company has been organized to construct an 8000-barrel refinery and cracking plant on an 18-acre tract at Main and East Road, Los Angeles County, California. The plant will utilize the Dubbs process of Universal Oil Products Company, or a similar process.

Officers of the company are Donald W. Douglas, president of Douglas Aircraft Company, board chairman; George W. Stratton, Douglas-Stratton Oil Company, president; William P. Andrews, Comet Oil Company, vice president and director of operations; A. L. Bergere, operator in Mid-Continent, New Mexico and California fields, secretary and treasurer; David C. Moore, comptroller, and Fred Davies, sales manager. Incorporators are Henry G. Reed, president of Petroleum Capital Corporation and vice president of Hill-Reed & Company; L. E. Manseau, president of Cuba-California Naphtha Company, and Douglas, Stratton, Andrews and Bergere.

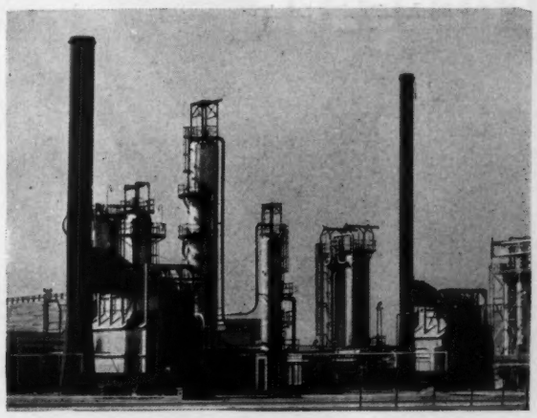
Clay Treating at Smiths Bluff: The Pure Oil Company is installing a clay treating process under license of Gray Processes Corporation in its gas polymerization plant at Smiths Bluff, Texas, to treat 1800 barrels of high-octane gasoline a day. It will be one of the largest installations to date for treating polymer gasoline to remove gum-forming materials without loss of octane rating.

Unity Modernizes: Capacity of Unity Petroleum Corporation's refinery at Kalispell, Montana, has been increased from 800 to 1100 barrels of crude and a tetraethyl lead blending plant added.

Vapor-Recovery for Tide Water: A gasoline-stabilizer and vapor-recovery plant for stabilization of 18,000 barrels of gasoline and 7,500,000 feet of cracking-plant vapors per day will be built at the Bayonne, New Jersey, plant of Tide Water Associated Oil Company by Petroleum Engineering, Inc., Tulsa.

Michigan Companies Merge: Imperial Refining Company, Grand Rapids, Michigan, organized in 1938, is being absorbed in a merger program by Mid-West Refiners, Inc., of Alma, according to B. J. Skinner, Mid-West president. Skinner also is a stockholder in and director of Imperial Refining Company. The merger elevates Mid-West Refiners, Inc., to the top place in Michigan - owned refining companies with an over-all charging capacity of 10,500 barrels daily, topping and cracking. Mid-West Refiners, Inc., organized in 1934, also operates Northern Refining Company plant at Alma under a lease. It is a 2000-barrel topping unit.

For Hot Oils



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Thicknesses from 1/64" to 1/4".
Sheets 40" x 40" and larger.

Against light oils at unusually high temperatures . . . against super-heated steam at extreme pressures . . . GARLOCK 7021 Compressed Asbestos Sheet Packing stands up—day in and day out . . . for months at a time.

Specially developed for severe service, GARLOCK 7021 gives superior performance against *all* light oil and steam conditions. Try 7021 in your plant!

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ENGINE EVOLUTION

an important factor in the selection of refining processes

NEWEST AND LARGEST PLANT for manufacturing tetraethyl lead is located at Baton Rouge, La. Strategically located to serve American refiners, this plant has sufficient reserve capacity to meet the increasing need for anti-knock fluids.

MAKING TRANSPORTATION BETTER AND MORE ECONOMICAL THROUGH RESEARCH

Here are some of the lines of research in which the Ethyl Research Laboratories are now engaged:

★ Application of higher compression ratios to commercial vehicles and farm tractors for more efficient utilization of today's improved fuels. ★ The development of super compression engines for the utilization of tomorrow's fuels of 90 to 100 octane number. ★ Supercharging of passenger and commercial vehicle engines. ★ Effect of volatility on anti-knock value. ★ Effects of sulphur. ★ Anti-knock tests on new fuels. ★ Study of the relation of lubrication to fuel and engine development. ★ Pre-ignition. ★ Studies of improved ceramics and metal alloys. ★ Instrumentation.

THERE has never been a point in the evolution of the automotive engine at which further progress has seemed either impossible or undesirable. Fuel improvement also has been continuous; in fact, much of the progress of engines has been made possible by better fuels. In the continuation of this development of engines and development of fuels, it is obvious that the most rapid strides will be made if the two go forward hand in hand. New fuels and new engines must each be evaluated with respect to the other. Therefore, the refiner who is planning production on a long-range basis may well keep in mind the prevailing trends in "engine evolution."

While it is impossible to predict the exact specifications of the engines of the next decade, it is reasonable to assume that the movement to more efficient engines will continue. This increase in the efficiency of the engines which will drive tomorrow's automobiles, buses, trucks and tractors can only be realized through the use of better fuels.

Here are a number of factors in future engine and vehicle design which, because of their effects on fuel requirements, are of direct interest to the refiner:

High Compression. Substantial increases in power and economy will be gained through the use of higher compression ratios, a change which is made possible by higher anti-knock value in fuels. An accurate evaluation of recently developed fuels can be made only after they have been tested in engines of very high compression ratios.

Supercharging. Since certain types of engines are not as well suited to increase in compression ratios as others, and because for certain applications supercharging is a much more effective means of utilizing the possibilities of high octane fuels, a rather widespread use of supercharging in future production engines may develop. It is possible that the relative performance of different types of high anti-knock fuels in supercharged engines will differ considerably from their relative performance in unsupercharged engines of high compression ratio. Therefore, experimental new fuels should be tested in supercharged engines as well as in high compression engines if their full potentialities and limitations are to be determined.

Intake Manifold Design. Should intake manifolds become larger with low gas velocities during the slow speed acceleration range, the distribution of mixtures of air and fuel to individual cylinders may be such that extremely high anti-knock value will be necessary in the more volatile range of our motor fuels. This means that hydrocarbons of relatively low boiling points and high anti-knock values would then be extremely desirable.

Fluid Drives. The use of fluid couplings between engine and transmission can offset, to a marked extent, the demands of intake manifolds which do not uniformly distribute fuel-air mixtures to individual cylinders at all speeds. Without the fluid drive, acceleration from low speeds requires that the engine operate for relatively long periods at wide-open throttle in the speed range where poor distribution has its most adverse effect. However, with the fluid drive, high engine speed is attained much more rapidly during acceleration from low car speeds and, as a result, distribution of fuel-air mixtures to individual cylinders is materially improved during this type of full-throttle acceleration.

Pre-ignition. Engines of high specific output not only require fuels of high anti-knock value, but also require that these fuels should not tend to pre-ignite. Unfortunately, some types of hydrocarbons which have high anti-knock value are apt to pre-ignite when subjected to high temperatures and pressures. Therefore, the fuels of the future must also be capable of withstanding, without pre-ignition, the conditions under which they are burned in more efficient engines.

It is apparent from the foregoing that new refining processes cannot be considered entirely on the basis of present anti-knock levels. While a particular process may produce a fuel having a high anti-knock value by today's standards, the continuous development of engines of higher efficiency will tend to raise anti-knock levels still further. The refiner who looks well ahead in the selection of refining processes should select those which produce gasoline having both high octane value and high lead susceptibility.

* * *

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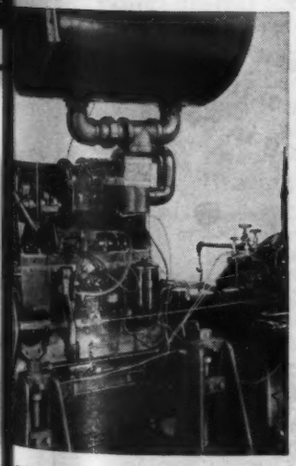
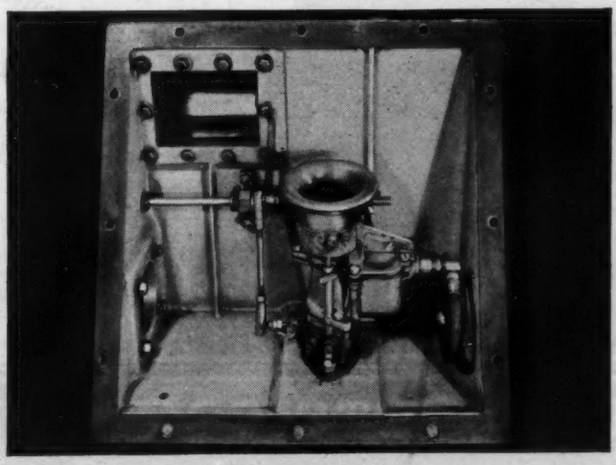
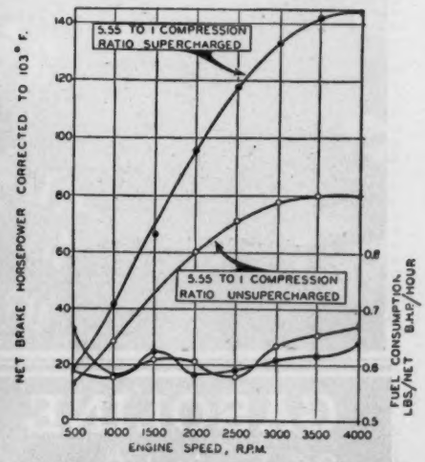


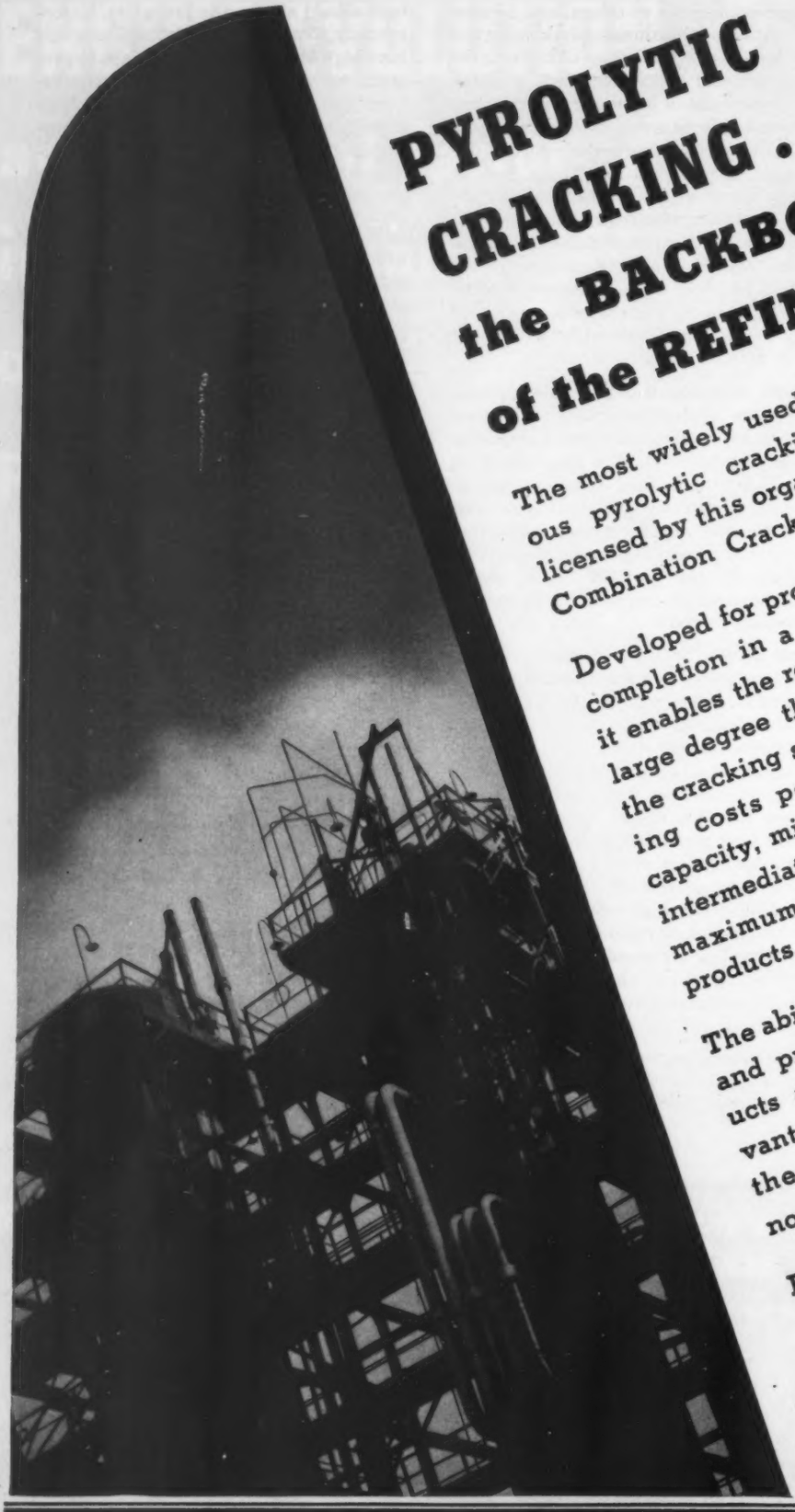
PREVIEW OF TOMORROW'S ENGINES. Above shows a general view of some of the apparatus now being used at the Ethyl Research Laboratories to develop further data on supercharging.



CARBURETOR PRESSURE CHAMBER. In preliminary research on supercharging, the carburetor often is surrounded by a box to which air is supplied from the supercharger. The carburetor then is exposed to the supercharge pressure both outside and inside, thus obviating any need for making it air-tight or for changing air-bleed jets. The photograph shows a carburetor in such a box, with the cover of the box removed.



NEARLY TWICE THE HORSEPOWER from the same sized engine. The above chart indicates the experimental results obtained by supercharging the engine of a popular American car. Graph shows brake horsepower and fuel consumption with and without supercharging.



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SCIENCE AND TECHNOLOGY

Abstracts prepared in co-operation with the

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by

THE LESLIE LABORATORIES

Traver Road, Ann Arbor, Mich.

under the supervision of

DR. E. H. LESLIE and DR. H. B. COATS

The abstracts here presented are selected from the current literature of science and technology to afford reference to fundamental information not easily available to all readers. Abstracts of articles appearing in readily obtainable trade journals are not included.

Photostat copies of original articles will be supplied at cost by the Leslie Laboratories. Complete or limited bibliographies covering special topics by title, by abstracts, or in complete manuscript, will also be prepared and furnished at reasonable cost by the Laboratories.

Fundamental Physical and Chemical Data

Thermodynamic Properties of Paraffins and Olefins, R. H. EWELL, *Ind. & Eng. Chem.* **32** (1940) pp. 778-83.

The paper presents a critical correlative study of the data available on the entropies and heats of formation, particularly at 25°C., of the paraffin or olefin hydrocarbons. By extrapolation of experimental data on the entropies and heats of formation of the lower hydrocarbons, a set of rules was deduced for estimating the entropy and heat of formation of any paraffin or olefin hydrocarbon at 25°C. These properties are tabulated for all paraffins through the octanes and for all olefins through the hexenes. These values can be used to calculate the approximate state of equilibrium in any hydrocarbon reaction. The equilibrium proportions of 2, 3-dimethyl-1-butene, 3, 3-dimethyl-1-butene, 2, 3-dimethyl-2-butene at 300°C. were calculated to be 25.4: 2.2:72.4, compared to Whitmore's experimental ratio of 31:3:61. Equilibrium calculations for the paraffins show that in the temperature range 150° to 175°C. all the isomers in any group of isomers have approximately the same free energy. The more highly branched isomers are more stable below this temperature range, and the straight-chain and less highly branched ones are more stable above this temperature range. Data are presented in tabular and graphical form, and a bibliography of 31 references is included.

Fundamental Phase Behavior of Hydrocarbons, J. E. SHERBORNE, *Petrol. Tech.* Feb. 1940, A.I.M.M.E. Tech. Pub. No. 1152, pp. 1-15.

A one-component system is discussed from the standpoint of the phase rule and extension is made to a pressure-temperature specific volume diagram. It is generally true that only liquid, liquid-vapor, and vapor phases need be investigated in considering hydrocarbon reservoir systems. In the case of a two-component system the phase rule indicates that it is possible for four phases to co-exist, but no case has been found in which more than two liquid phases co-exist. The discussion in the article is limited to systems with one liquid phase. In a reservoir hydrocarbons are considered to exist as varying mixtures of the component natural gas and the component crude oil. The pressure-temperature-composition diagram is considered for a two-component system with only one liquid phase, and the significance of dew- and bubble-points are discussed.

P-V-T Relations for Propane, W. W. DESCHNER AND G. G. BROWN, *Ind. & Eng. Chem.* **32** (1940) pp. 836-40.

The investigation reported was undertaken to increase the information on the physical and thermal properties of the petroleum hydrocarbons. Previous work on the properties of propane is reviewed. Purification of the propane used is described. Temperature range covered in the work was 30° to 336.16°C. Decomposition of propane was noticeable at the latter temperature. The pressure range was 1 to 120 atmospheres. Data are given on the P-V-T relationship, critical constants, saturated liquid and vapor densities, vapor pressure, enthalpy, and fugacity.

Correlating Vapor Pressure and Latent Heat Data, D. F. OTHMER, *Ind. & Eng. Chem.* **32** (1940) pp. 841-56.

The vapor pressures of liquids, of solids, of solutions having a nonvolatile component, or solutions having two or more volatile components, of hydrates and of other substances undergoing decomposition give straight lines when plotted on logarithmic paper against values of the vapor pressures at corresponding temperatures of a reference substance. The slope of the line is equal to the ratio of the latent or other total heat quantity involved in the evolution of the vapor to the latent heat of the reference substance. This indicates the validity of the equation $\log P = L/L' \log P' + C$, where P and P′ are pressures, L and L′ molal latent heats, respectively, of the two compounds at the same temperatures, and C is a constant. Plots are made to illustrate the utility of this relationship in checking and correlating vapor pressure data, and it gives lines more nearly straight than are obtained by any other method of plotting that has been suggested. Latent heats have been evaluated and checked; and heats of fusion, of hydration, of dissociation, of dilution or solution, of chemical reaction, are shown to be related to the method so that they can be calculated. Freezing points of salt solutions, enthalpy charts, distillation relationships, composition of vapors from boiling binary solutions, constant-boiling mixtures, and other phenomena relating to the disengaging of vapors from a liquid phase can also be studied and evaluated by this general procedure. A comprehensive relationship is developed that includes all of the other general methods used for graphic vapor pressure representation. Some other useful forms of equations for similar calculations are suggested.

Retrograde Condensation, D. L. KATZ AND F. KURATA, *Ind. & Eng. Chem.* **32** (1940) pp. 817-27.

The purpose of the paper is to describe the phase behavior of simple and complex fluids including any condensation phenomena that may be considered retrograde. The significance to the petroleum industry of phase behavior that may be termed "retrograde" is discussed. The term "retrograde condensation" was first used by Kuenen at Leiden in 1892, to describe the behavior of a binary solution during isothermal compression above the

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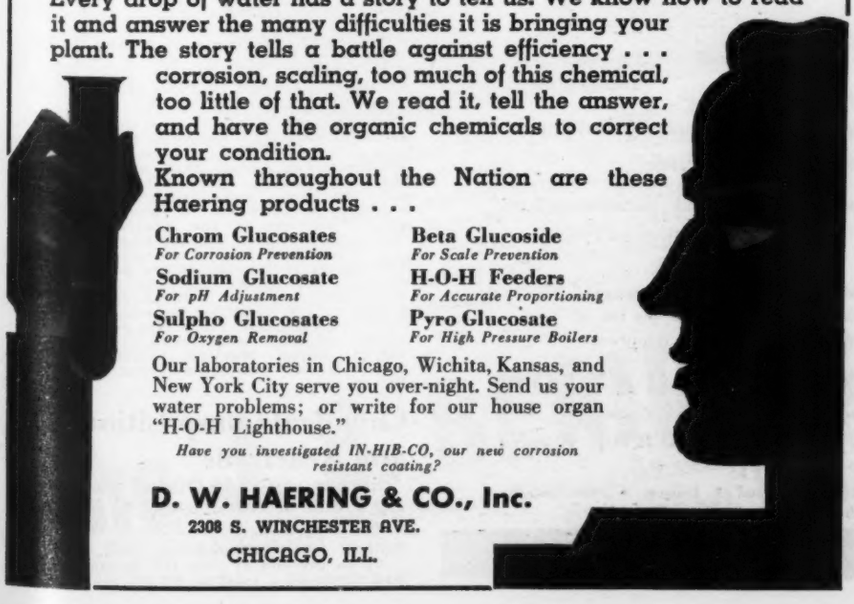

critical temperature of the solution. Neither the contemporaries of Kuenen nor the recent investigators of the petroleum hydrocarbons have been consistent with Kuenen or with one another in the exact interpretation of the term. The phase behavior of simple and complex systems may be adequately described without the use of the term "retrograde condensation." The paper presents the phase behavior of simple and complex substances, and includes laboratory results on the phase relations of a mixture of natural gas and natural gasoline. The development of the concepts of vapor-liquid equilibria indicates that the phase behavior observed by the early investigators has not been utilized in present-day developments. The use of the term "retrograde condensation" is discussed; simple rules of nomenclature are recommended that indicate that phase behavior can be adequately and more accurately described without the use of the term "retrograde condensation." The article is well illustrated with diagrams, includes tabulated data, and 54 references to the literature.

Solubility of Methane in Benzene, F. P. SCHOCH, A. F. HOFFMANN, A. S. KASPERIK, J. H. LIGHTFOOT, AND F. D. MAYFIELD, *Ind. & Eng. Chem.* **32** (1940) pp. 788-91.

The importance of accurate P-V-T-X data for hydrocarbon solutions is stressed. An apparatus is described for measuring P-V-T-X relationships of hydrocarbon solutions up to a pressure of 400 atmospheres. Specific volume and bubble-point data at 100-27°F. are presented for eleven mixtures of methane and benzene. The solutions ranged in concentration from 20 to 76 mole percent of methane corresponding to bubble-point pressures of 1500 to 5200 pounds per square inch absolute. The method of procedure in the work is described in some detail, and the results are presented in tabular and graphical form.

Physical Properties of Some Purified Aliphatic Hydrocarbons, D. B. BROOKS, F. L. HOWARD AND H. C. CRAFTON, JR., *Bur. Stand. J. Res.* **24** (1940) pp. 33-45.

The vapor pressure curves, freezing point, refractive index, density and its variation with temperature were determined for eleven aliphatic hydrocarbons. Eight of these were synthesized, one was isolated by fractionation from a commercial synthetic crude, and two were obtained from commercial sources. All were further purified by distillation in fractionating columns of high efficiency. The hydrocarbons included were: 3:3-dimethylbutene-1, 2:3-dimethylbutene-1, 2:3-dimethylbutene-2, 2:2-dimethylbutane, 2:3-dimethylbutane, 2:3:3 - trimethylbutene - 1, 2:2:3 - trimethylbutane, 3-ethylpentane, 2:3:4-trimethylpentane, n-heptane, and 2:2:4-trimethylpentane.

Physical Properties of Purified 2:2:3-Trimethyl-Pentane, D. B. BROOKS, F. L. HOWARD, AND H. C. CRAFTON, JR., *Bur. Stand. J. Res.* **23** (1939) pp. 637-41.

2:2:3-Trimethylpentane was prepared synthetically and after fractionation was obtained in a state of great purity. The method of preparation is described. The resulting product was of such purity that a good freezing point was obtained. The freezing point and melting point were determined in an apparatus in which the rate of heating or cooling could be accurately controlled. Other properties measured included the vapor pressure data, refractive index and density at different temperatures.

Simple Petroleum Tables for Use with Density Hydrometers, V. SCOTT, *Jour. Inst. Petr.* **26** (1940) pp. 235-45.

Two tables are given in the paper, one showing the change in density of petroleum oils with change in temperature, and (2) for conversion of density in g./ml. to weight in air in pounds per Imperial gallon. If the tables are used in conjunction with a density hydrometer, the tables enable the weight of a known volume of oil, the volume of a known weight of oil, or the change in volume of a given quantity of oil with change in temperature to be obtained by simple computations. Examples are given. A note is appended on the accuracy of density determinations as made by means of British Standard density hydrometers. The derivation of the tables is also explained.

Thermal Data on Organic Compounds. XX. Modern Combustion Data for Two Methylnonanes, Methyl Ethyl Ketone, Thiophene and Six Cycloparaffins, *Jour. Amer. Chem. Soc.* **62** (1940) pp. 1505-7.

The heats of combustion of 10 substances were determined at 25°C. and constant volume by use of a bomb calorimeter that was calibrated for precise measurements. The substances studied included: 2-methylnonane, 5-methylnonane, methylcyclopentane, ethylcyclopentane, cyclohexane, methylcyclohexane, n - heptylcyclohexane, n - dodecylcyclohexane, methyl ethyl ketone, and thiophene. The heats of combustion and heats of formation at constant pressure were calculated. A summary of the experimental and derived data is included.

Properties of Flammable Liquids, Gases, and Solids, *The Associated Factory Mutual Fire Insurance Companies, Ind. & Eng. Chem.* **32** (1940) pp. 880-4.

A four-page table is given that shows the pertinent data with respect to the fire hazards of liquids, gases, and solids that are ordinarily handled in industrial plants. These data have been assembled from the results of tests made by the Factory Mutual Laboratories and from other data carefully chosen as the most reliable. The table shows the closed- and open-cup flash point, the explosive limits, auto-ignition temperature, the susceptibility to spontaneous heating, specific gravity, vapor density, melting point, boiling point, and suitable extinguishing agents.

Physical Constants of Asphaltic Bitumens. Part II, R. N. J. SAAL, K. MEINEMA, AND P. C. BLOKKER, *Jour. Inst. Petr.* **26** (1940) pp. 246-55.

A survey is given of some electrical properties of asphaltic bitumens in continuation of a publication already issued from the same laboratory on other physical constants of these substances. The dielectric strength, dielectric loss, and dielectric constant of asphaltic bitumen are of importance in applying bitumen in the electrical industry, where it is used, in pothead compounds, sealing compounds for transformers, inpregnation material for condensers and insulation material for cables. Methods of measuring these properties, as well as electrical conductivity, are described in some detail. Results are tabulated for steam reduced Venezuelan bitumen, steam reduced Mexican bitumen, blown Mexican bitumen, bitumen from cracked residue, and light-colored bitumen.

Chemical Compositions and Reactions

Survey of Crude Oils of the Producing Fields of Arkansas, O. C. BLADE AND G. C. BRANNER, *U. S. Bur. of Mines, Report of Investigations No. 3486,* Jan. 1940

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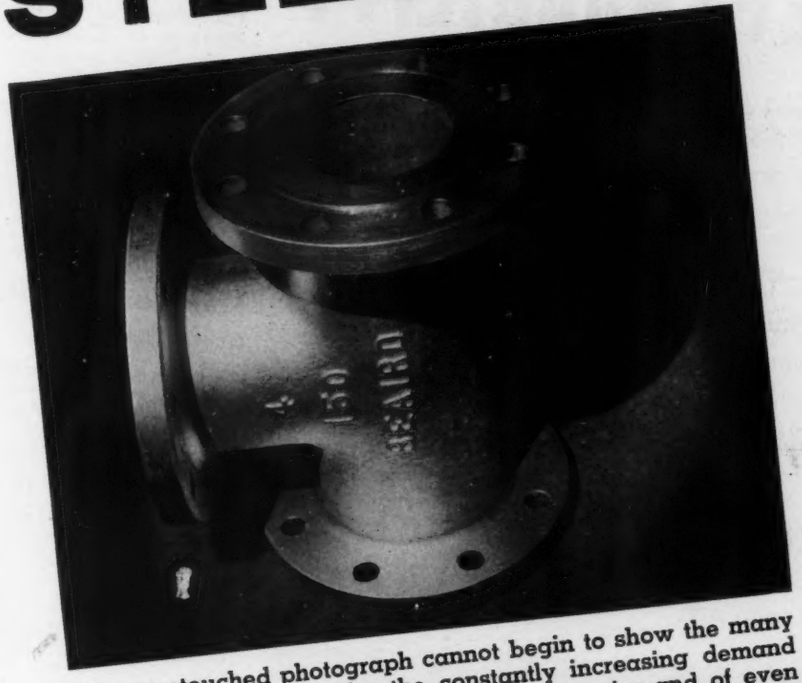

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crude oil. Peak production was attained in 1925. The fields are situated in the southern part of the state and have been an important factor in the development of the northern coastal plain region of the Mid-Continent area. The report describes the principal fields, and has reference to forty-five samples of typical crude oils from the fields. Possibly the most prominent property is a high sulfur content. Out of forty-five samples analyzed, thirty-five have 0.7% sulfur or more, the average for all is 1.51%. The physical and chemical properties change as the sulfur content varies. In classification the largest number of samples is in the intermediate base group, the second largest in the naphthene intermediate oils, paraffin and naphthene base types, as such, are also produced.

The Hydrogenation of Ethylene at Surfaces of Certain Oxides. I. Zinc Oxide and Zinc Chromite, J. F. WOODMAN AND H. S. TAYLOR, *Jour. Amer. Chem. Soc.* **62** (1940) pp. 1393-6.

Zinc oxide and zinc chromite have been shown to act as catalysts for the hydrogenation of ethylene with measurable velocity at and above room temperature. At 56° C. the reaction velocity on zinc oxide has been shown to be independent of hydrogen, ethylene and ethane partial pressures with a range of variation of these quantities. Ethylene has been shown to polymerize slowly on zinc oxide at 218° C. without appreciable formation of permanent gases. At 445° C. polymerization is rapid, but accompanied by the formation of large amounts of hydrogen and methane. Small amounts of water vapor have been shown to poison the surface of zinc oxide completely at 56° and even at 400°. This effect is responsible for the failure of previous investigators to observe the activity of this catalyst.

The Hydrogenation of Ethylene at Surfaces of Certain Oxides. II. Molybdenum Oxide Compounds, J. F. WOODMAN, H. S. TAYLOR AND J. TURKEVICH, *Jour. Amer. Chem. Soc.* **62** (1940) pp. 1397-99.

A catalyst prepared by decomposition and reduction of ammonium nickel molybdate at 300° C. is active at —80° C. in the hydrogenation of ethylene. Magnetic susceptibility measurements, together with poisoning experiments using hydrogen sulfide, have suggested that this activity is caused by metallic nickel, very highly dispersed. Catalysts prepared from ammonium paramolybdate and ammonium phosphomolybdate have shown negligible activity for ethylene hydrogenation below 256° C.

Destructive Hydrogenation of High-Molecular-Weight Polymers, V. N. IPATIEFF AND R. E. SCHAAD, *Ind. & Eng. Chem.* **32** (1940) pp. 762-4.

Destructive hydrogenation under pressure in the presence of nickel oxide and molybdenum oxide has been used to show the presence of naphthenic hydrocarbons in high-boiling olefin polymer. Investigators recorded it of interest to apply this tool to other hydrocarbons having large molecules, especially rubber and synthetic rubberlike polymers. The destructive hydrogenation of rubberlike isobutene polymers resulted only in paraffinic hydrocarbons, thus showing that the original rubberlike polymers had long aliphatic carbon chains. The destructive hydrogenation of butadiene thermal rubber and of natural rubber gave only naphthenic hydrocarbons. Hydrogenation of isoprene yielded isopentane as well as cyclic hydropolymers.

Liquid-Phase Hydrogenation of p-Cymene, K. A. KOBE AND A. VITTONE, *Ind. & Eng. Chem.* **32** (1940) pp. 775-7.

Most of the work on the utilization of p-cymene has been directed toward its oxidation, or a sequence of reactions to produce thymol or carvacrol. In the investigation reported a study was made of the liquid-phase hydrogenation of p-cymene to p-menthane, which latter compound is the parent member of the p-menthane series of terpenic substances. The optimum conditions were determined for the liquid-phase hydrogenation of p-cymene with a nickel catalyst. The physical properties of p-menthane were determined, and are reported in tabular form. These included vapor pressure, refractive index, and density.

Chlorides and Hydrochlorides from 1-Hexyne, G. F. HENNION AND C. E. WELSH, *Jour. Amer. Chem. Soc.* **62** (1940) pp. 1367-8.

Chlorination of 1-hexyne in inert solvents in the presence of antimony pentachloride gives trans-1.2-dichloro-1-hexene and 1,1 2.2-tetrachlorohexane as the sole products. Bismuth chloride is an effective catalyst for the addition of hydrogen chloride to 1-hexyne. The reaction of chlorine with 2-chloro-1-hexene in the presence of antimony pentachloride leads to the formation of cis-1,2-dichloro-1-hexene and 1.1,2.2-tetrachlorohexane. Hydrogen chloride could not be added to either cis- or trans-1,2,dichloro-1-hexene.

Manufacture: Processes and Plant

Chemical Engineering Opportunities in Petroleum Refining, CHEM. & MET. EDITORS, *Chem. & Met. Engr.* **47** (1940) pp. 415-22.

The first part of the article reviews the structure and the outlook of the petroleum industry. It is the largest and most important of the chemical process industries, and is the largest single employer of chemical engineering graduates. The statistics of the industry are reviewed, including investment, volume of business, employees and annual payroll, purchases of products, equipment and services, expenditures for research, and the like. The organization of the industry is outlined, and the trends in the various branches of the industry briefly discussed. A table is given showing refineries in the United States with capacities of more than 20,000 barrels per days as of January 1, 1940. The second part of the article deals with the chemical engineer in the petroleum industry, describing his functions, the kind of work he does, the lines of promotion, salaries, and working conditions.

Heat Transfer Coefficients in Glass Exchangers, T. J. THOMPSON AND A. S. FOUST, *Chem. & Met. Engr.* **47** (1940) pp. 410-14.

The investigation was made to increase available information with regard to the thermal characteristics of Pyrex glass in heat exchangers. The original purpose of the research was the evaluation of the factors controlling the performance of such an exchanger in dehumidifying waxed gas. The difficulties in correlating the results later required the addition of measurements of coefficients from water to water and from steam to water. Among the significant facts found were: (1) with these data, performance of double-pipe heat exchangers can be accurately predicted under various conditions; (2) surprisingly high coefficients are possible for dehumidification if the gas stream is flowing at moderately high velocities; (3) distribution of heat flux over four passes in

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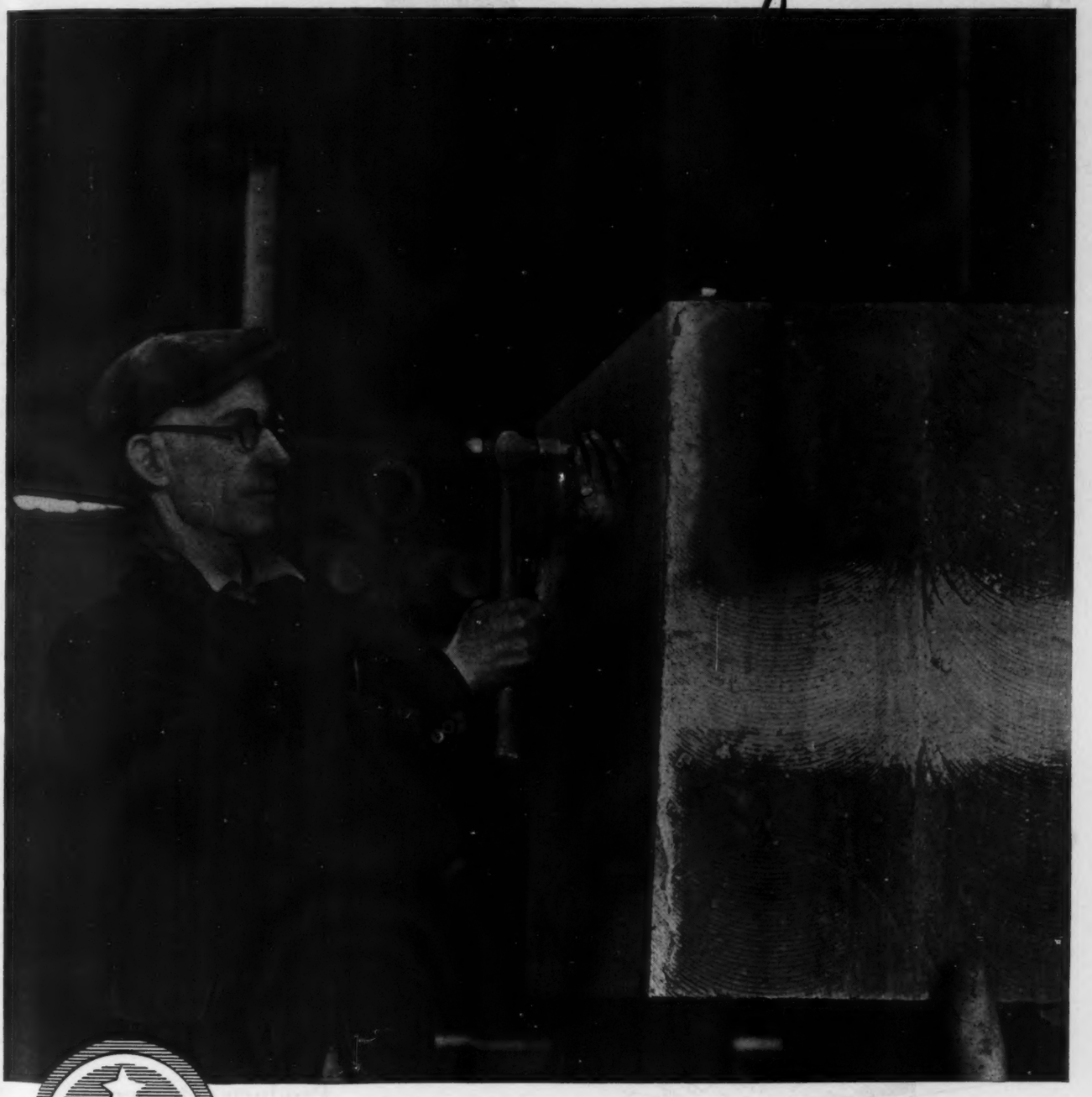

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uniform; and (4) evidence indicates that thermal conductivities for pyrex are lower than previously published values. The increased use of glass as a construction material by the chemical engineer makes it necessary that he extend his knowledge of its thermal properties. The data secured are presented in some detail in both tabular and graphical form.

Pressure Drop and Liquid Holdup in a Packed Tower, E. L. PIRET, C. A. MANN, AND T. WALL, JR., *Ind. & Eng. Chem.* **32** (1940) pp. 861-3.

Data are presented on various operating characteristics of a large tower filled with large-diameter solid packing. The data indicate that Chilton and Colburn's equation for pressure drop can be applied with a fair degree of accuracy to packings up to 1¾ inches in diameter. An increase in holdup is noted above but not below the loading point. The holdup data are in general agreement with those of others. It is shown that for low rates of air flow and for high rates of liquid flow the pressure drop is materially different for countercurrent and parallel flow. The results of the investigation appear in a general way to confirm the many data obtained using small experimental towers.

Hazards Associated with Butadiene and Its Peroxides, D. A. SCOTT, *Jour. Inst. Petr.* **26** (1940) p. 272.

The author notes that certain information concerning unusual hazards that may be encountered in working with butadiene and related compounds has come to his attention. Butadiene, when heated under pressure, may undergo violent thermal decomposition. In one instance, explosive decomposition with carbon formation occurred on heating butadiene in a stainless steel bomb. In contact with air or oxygen, butadiene may form peroxides that are violently explosive and that can be detonated either by mild heating or by mechanical shock. In one instance solid butadiene, exposed for only a short time to oxygen at sub-atmospheric pressure, absorbed sufficient oxygen so that on warming slightly above the melting point a violent detonation occurred. After emptying a storage tank of crude butadiene some polymer was found in the bottom of the tank. The polymer contained 0.095 equivalents of peroxide oxygen per 100 grams, and could be detonated easily by a hammer blow. Subsequent investigation showed that the peroxide could be destroyed safely by treatment with caustic soda. Thus butadiene might be freed of peroxides by storage over caustic or by passage through a caustic wash.

Further Improvements in Drum Construction, *Chem. & Met.* **47** (1940) pp. 406-9.

This article is in the nature of a progress report, and is related to one that appeared in Chem. & Met. Engr. two years ago, which article gave the results of tests on a new type of 55-gallon steel drum with 20-gage sidewalls and 18-gage heads. Acceptance of the new drums by manufacturers and shippers resulted in considerable savings, and favorable comments were received from most users. A few complaints and adverse comments were the reason for the investigations and recommendations on which a report is made in the current article. The tests made and the results secured in these tests are given and discussed in some detail. It was found that the use of stiff steel of high yield point reduces the denting and the flattening of the rolling hoops. The I.C.C. 5E 55-gallon drum with 18-gage heads and 20-gage sidewall is intended for the shipment of liquids of low specific gravity such as alcohol and solvents. The drum should not be overloaded. The committee recommends that the maximum net weight of contents therein should not exceed 450 pounds. Better quality sheet steel is now available, and improvements in design and fabrication have been made.

Products: Properties and Utilization

Cutting Fluids—The Influence of Proper Selection upon Efficiency of Machine Tools, A. H. LLOYD AND H. H. BEENY, *Can. Metals Met. Inds.* **3** (1940) pp. 97-9.

A neat cutting oil is recommended by the authors for all automatic and semi-automatic machines. A straight oil is used on machines performing hobbing, gear-cutting or other types of forming. A super-fatted sulfurized straight oil is used on high-tensile steels where great accuracy and smooth finish are required. A syphon drip-test has been developed to determine the corrosive quality of emulsions used for cutting. Samples of the emulsions are placed in conical beakers and the emulsion allowed to drip slowly onto a cast-iron block with milled recesses. The block is made from a metal similar to that used for lathe beds and brass and steel chips

Products in season

Motorists are burning more gasoline this summer than ever before and the heavy gasoline stocks are going down—2 million barrels in a single week

There's a temptation to run too much crude to make the extra gasoline you need, but that leads to trouble It makes too much of other products that you *don't* need—gas oil and distillate stocks are climbing right now

Here's the answer

In the motoring season, make the highest possible yield of premium gasoline from the crude you run—and the least of other products

Dubbscracking is the way to do that

In the heating season just turn it around Make the highest yield of premium furnace oil and the least gasoline

Dubbscracking is the way to do that, too

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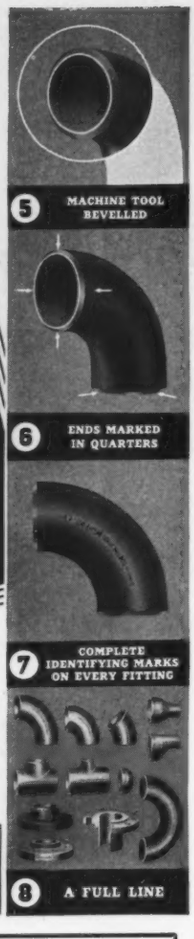
If it hasn't these 8 features it isn't a WeldELL



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As a close regulator of pressure on constant-speed pumps, the C-F Compressor Regulator has no equal. Any excess of discharge pressure flows through and is relieved without appreciable variation in the suction line. Lever-type regulator is here shown. Spring-loaded type is also available and is equally sure-working. Ask for Bulletin No. 130, also new catalog of Chaplin-Fulton Regulators.

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are placed in each recess. The test is usually run for three or four days. It is noted that sintered hard carbide tools apparently cut as well dry as in the presence of a cutting fluid.

Some Experiments on Seizure Between Lubricated Hard Steel Balls, D. CLAYTON, *Jour. Inst. Petr.* **26** (1940) pp. 256-71.

The investigation reported was part of a general program of research in lubrication in the engineering department of the National Physical Laboratory. Previous results have been published in which the 4-ball apparatus was used and standard conditions maintained throughout the test. In the present experiment an effort was made to determine the effect of varying conditions of test — e.g., speed, increase of load, interruption of seizure, and rigidity of the chuck mounting. In tests with a continuously increasing load, the breakdown loads for mineral and fatty oils were 40 per cent higher than in tests at a series of constant loads, and rather more for an extreme-pressure lubricant; the wear values corresponded with those found in previous tests for the particular loads. Tests at half and double the normal speed showed that with increase of speed the breakdown load decreased, the time to seizure decreased, and the wear increased. Interrupting the seizure with a mineral oil by removing the load showed that most of the wear occurred in the early part of the seizure period; on restoring the load, even after several minutes, the friction immediately rose to its high value. This indicated that the continuance of high friction with this type of oil was not merely caused by high temperature at the contact persisting from the early period of the failure. Considerable increase of load could be made after recovery before a second seizure occurred.

The Synthesis of Lubricating Oils by Condensation Reactions, Part II, W. R. WIGGINS, T. G. HUNTER, AND A. W. NASH, *Jour. Inst. Petr.* **26** (1940) pp. 225-34.

The service characteristics of two synthetic lubricating oils were determined by means of an engine test. Synthetic oil S/1 was made by the condensation of chlorinated paraffin wax with benzene using an aluminum catalyst. Synthetic oil S/2 was made by the condensation of chlorinated paraffin wax with benzene using aluminum chloride catalyst. The service characteristics evaluated were: engine wear, oil consumption, carbon deposits, and condition of the oil in the crank-case. The synthetic oils were definitely found to be superior to the proprietary brand reference oil from the standpoint of wear and from that of oil consumption. The synthetic oils were inferior as regards cylinder deposits. With respect to the condition of the oils after use, it was found that all were similar.

An Efficient Low-Holdup Laboratory Column, M. L. SELKER, R. E. BURK, AND H. P. LANKELMA, *Ind. & Eng. Chem., Anal. Ed* **12** (1940) pp. 352-5.

The authors note that the efficient separation of small quantities of close-boiling liquids is a problem of increasing importance, and that in order to separate mixtures of hydrocarbons that differ in boiling points by only 2° or 3° C. a fractionating column of 80 to 100 theoretical plates is required. A new type of column is described that combines high efficiency and low holdup. It is of all-glass construction and is simple and economical. The pressure drop of the column is small, so that it can be used at pressures of down to 0.4 mm. of mercury. Construction of the column is described in some detail, and also illustrated. Tests of the efficiency of the column are given.

Microdetermination of Sulfur in Organic Compounds, L. T. HALLETT AND J. W. KUIPERS, *Ind. & Eng. Chem., Anal. Ed.* **12** (1940) pp. 357-9.

Two forms of an absorber that can be used for the determination of sulfur by the combustion method are described. One meets the needs of the average laboratory and allows more rapid burning of the sample. It is designed so that the products of combustion can be washed from the absorber without removing the tube from the furnace. Sulfur trioxide mist, which once formed cannot be absorbed, is eliminated with this type of absorber except in those infrequent cases where the compound burns very rapidly. The other absorber meets the needs of routine laboratories where a large number of sulfur compounds must be analyzed. An electroprecipitator positively dissipates the sulfur trioxide mist and any lower oxides of sulfur are oxidized to sulfur trioxide because of the formation of ozone. This absorber retains the advantages of the one first described, but allows slightly more rapid burning, uses water as an absorbent, and allows the titration of the sulfate using as indicator tetrahydroxyquinone as soon as the washings are removed from the absorber.

45% INCREASE IN CAPACITY

by Leading Lubricating Oil Manufacturers puts Seal of Approval on MEK-Benzol Solvent Dewaxing

THE FACT that seven leading lubricating oil manufacturers licensed to use the MEK-Benzol solvent dewaxing process have increased their installed capacity 45% within 2 years is important to every refiner.

What better proof is there of the ability of this process to produce highest yields of fully dewaxed oil from a wide variety of wax-bearing stocks at low cost than the satisfaction of these users—expressed in *increased use?*

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New Equipment for the Modern Plant

Lantern

BURGESS BATTERY COMPANY

A safety lantern designed for use in oil fields and other places where explosive atmospheres are encountered has been announced by Burgess Battery Company, Freeport, Illinois.

Burgess Lantern

The lantern, designated Model AL4, features a twin-bulb socket to permit replacing a burned-out bulb with "a flick of the thumb." An automatic ejector throws out broken bulbs. The reflector is covered by a heat-treated glass dome, protected by a wire guard. The body is made of bonderized steel with cadmium trim, and is mounted on a swivel base to permit setting the lantern down with the light tilted at any desired angle.

Welding Positioner

CULLEN-FRIESTEDT COMPANY

A new welding positioner, designated Model 12, with a rated capacity of 1200 pounds and designed to be tilted 135° from horizontal and revolved through a full circle regardless of angle of tilt, has been announced by Cullen-Friestedt Company, Chicago. It is self-locking in any position.

The table is removable for attachment of special jigs or fixtures, and is adjustable in height. By mounting the positioner-operating mechanism on a special base, large and bulky work can be fully rotated when tilted either vertical or to 135° without any interference from floor or pedestal mounting.

Cullen-Friestedt Welding Positioner

The unit may be obtained fully powered with independent motor and controls for table tilt and table rotation, while power for table rotation can be obtained with either constant or variable-speed drive. It is also furnished for manual operation with independent hand wheel for table tilt and table rotation, or a combination of manual and power operation.

Gauge Strips

J. A. CAMPBELL COMPANY

A new gauge strip for oil, gasoline and water tanks which may be added to, foot by foot, has been announced by J. A. Campbell Company, 645 East Wardlow Road, Long Beach California.

The strips are supplied in units of one foot each, locked together by foot numeral inserts described as clearly visible at a distance. Cast of a zinc base alloy, the strips are available in molybdenum or chromium finishes. Numerals and graduations are raised. The strips are 2 inches wide and ⅛-inch thick, may be mounted on a wooden board or metal and fastened to the tank alongside the gauge glasses.

Welder

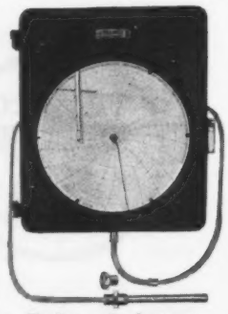
WESTINGHOUSE ELECTRIC & MANUFACTURING COMPANY

A new all-purpose portable AC welder designed for general utility service and production welding of every type has been announced by Westinghouse Electric & Manufacturing Company, East Pittsburgh, Pennsylvania. Standard models operate on either 220 or 440 volts, and are complete self-contained.

From 20 to 250 amperes of welding current is available in 27 current steps, with increments proportioned to meet the needs of welding with a wide variety of electrode types and diameters. Current adjustment is obtained by inserting the bayonet plugs in the proper receptacles, and current values are indicated in large numerals.

A built-in De-Ion breaker is provided to insure protection against long-sustained overloads, such as might occur

Westinghouse Portable Welder



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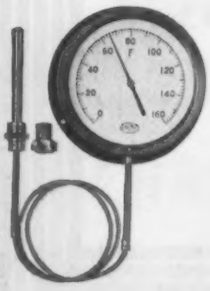
Both are PALMER products and very fine instruments.

Just as Palmer "Red-Reading-Mercury" indicating Thermometers are known everywhere for sensitive and accurate Temperature Readings, just so Palmer's latest products: **"Recording" and "Dial" Thermometers** carry this same high quality and you will be amazed at their accuracy and sensitive reading.



(Bulletin 1300—Recording; Bulletin 1500—Dial)

THE PALMER CO.

MANUFACTURERS: INDICATING—RECORDING—DIAL THERMOMETERS

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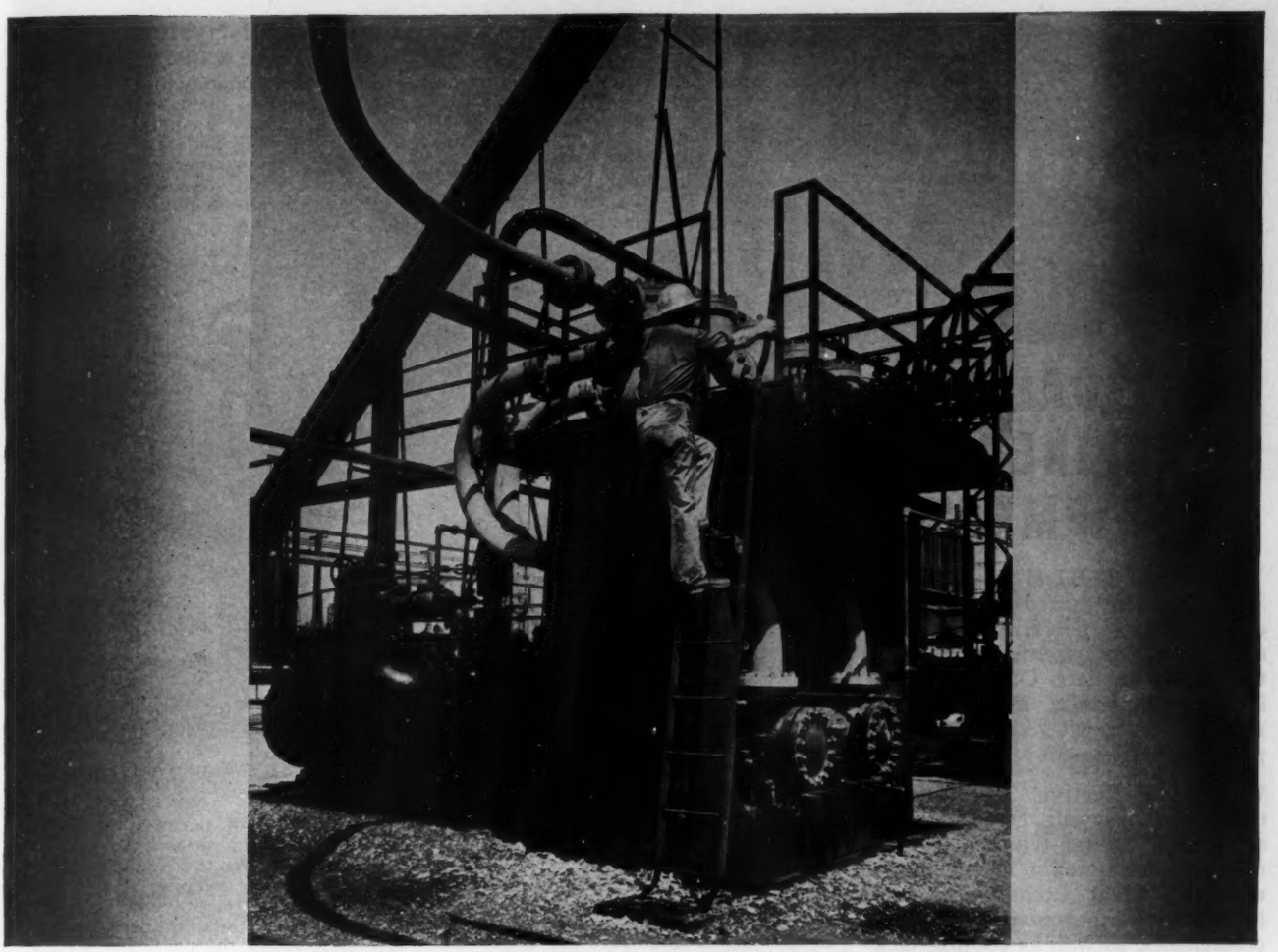

SURGE BLOCK METHUSELAHS

Surge blocks have a definite function to perform. So long as they perform it well, hot oil pumping is both easier and more economical. But if block maintenance and replacement costs mount up, they can quickly offset any saving in pump maintenance costs.

Making surge blocks of cast 4—6% Chromium-Molybdenum steel has proved a notable step forward in holding down pumping costs — since this steel not only retains its strength after repeated heating and cooling, but has adequate corrosion resistance.

For example: in one refinery where high sulphur-content oil is being handled, changing to Chromium-Molybdenum steel has lengthened block life over 400%. The effect on maintenance costs is obvious.

Complete data on Chromium-Molybdenum steel and the other Molybdenum steels especially suitable for refinery equipment use will be found in Sections 8 and 9 of our technical book, "Molybdenum in Steel." Either these two sections or the complete book will be sent on request to interested executives and engineers.

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by accidentally leaving the machine short circuited. Open circuit or striking voltage is on the order of 80 volts at 20 amperes, and ranging down to 50 volts at the highest current rating.

The welder is enclosed in a steel case, mounted on three wheels. It is furnished complete with all accessories, including welding helmet and lens, electrode holder, all leads, and a 17-pound assortment of electrodes.

Brake Lining
GATKE CORPORATION

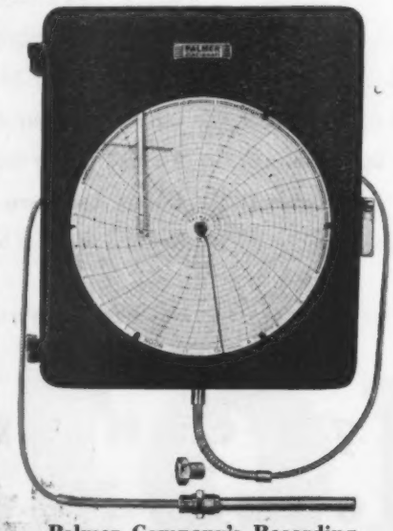
A new asbestos friction material for brake lining and clutch facings, of woven-moulded design to provide a high frictional coefficient with uniformity under varying conditions of load and temperature, has been announced by Gatke Corporation, 228 North La Salle Street, Chicago.

Gatke Asbestos Brake Lining

It is supplied to accurate dimensions in all shapes and sizes for brake and clutch requirements.

Recording Thermometer
THE PALMER COMPANY

A mercury-actuated recording thermometer, with each part designed for easy working and maximum strength, has been announced by The Palmer Company, 2501 Norwood Avenue, Cincinnati, Ohio. In a 12-inch case, the instrument is described as extremely sensitive and providing accurate temperature recording.



Palmer Company's Recording Thermometer

Tank Thief System
BLACK, SIVALS & BRYSON, INC.

A new tank gauging and thiefing system designed to make tankage as safe against corrosive elements in gas and fluids in sour-oil fields as is the tubing, separator, well connections and piping to storage tanks, has been announced by Black, Sivalls & Bryson, Inc., Oklahoma City.

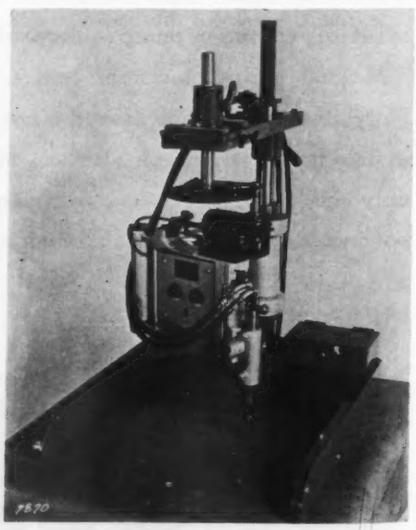
THE BS&B GAUGING & THIEFING SYSTEM

The equipment permits running the gauge tape and thief into the tank without opening the tank to atmosphere, thereby keeping tanks under constant pressure, preventing evaporation losses, minimizing corrosion losses and eliminating the necessity for gaugers to wear gas masks.

Cutting Machine
OHMSTEDE MACHINE WORKS

A shape portable cutting machine with a range of 56 inches lengthwise and 24 inches laterally has been announced by Ohmstede Machine Works, Beaumont, Texas.

The unit uses high-strength aluminum alloys with oversize anti-friction bearings in aluminum alloy arms sealed from foreign material. A variab.e-speed



Ohmstede Cutting Machine

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motor is equipped with a filter to provide long life.

In operation, a templet of ¼-inch plywood, fastened to the templet mandrel, acts as a guide for the spiral cut roller controlling the movement of the blow pipe through two pivoted arms. The blow pipe and motor are attached to the outer end of the second pivoted arm. The motor rotates the roller, which may be held in contact with the templet either by hand or spring tension. As the motor proceeds along the contour of the templet, the torch cuts a reproduction of the shape.

In starting a cut, an offsetting device is used to keep a blemish from appearing on the finished piece. The torch is first offset by either depressing or raising a lever located beside the motor. Movement of the lever places the torch on either side of the finished line of the cut. The metal is then pierced and the torch moved in to the line of cut. When the torch reaches a point in axial alignment with the roller that is contacting the templet, the mechanism locks, a clutch between the motor and roller is engaged and the roller proceeds along the contour of the templet.

Circles from 2¾ to 24 inches in diameter, and straight lines as long as 56 inches in any direction may be cut with special attachments.

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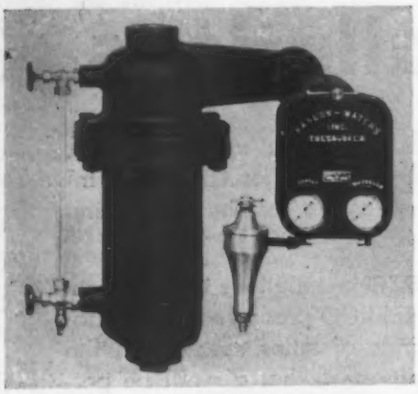
Type 850

LEVEL CONTROLLER

Especially designed for control of all gravity liquids at high working pressures and temperatures.



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● **NO STUFFING BOX**

NO Leakage . . . NO Friction

Major operators find the most difficult control problems made easy with the HANLON-WATERS 850 Level Controller—These customers are our best salesmen.

Torsion tube housing extension will dissipate heat thereby eliminating necessity of using finned cooling section on high temperature service. Pilot mechanism extremely sensitive, high capacity, fully adjustable as to direction of action and throttling range . . . All lengths—Any pressure . . . Fabricated to API-ASME specifications.

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Pipe Threader

TOLEDO PIPE THREADING MACHINE COMPANY

A new self-contained 1- to 2-inch ratchet threader, designated Simpact, has been announced by Toledo Pipe Threading Machine Company, Toledo, Ohio.

Toledo's Simpact Threader

The tool uses high-speed steel dies which are changed from one size to another by pushing the size selector buttons and slipping the dies in the proper steps. The dies are backed by tapered steps to provide smooth, long-tapered threads. A three-jaw rear gripping device is employed, the tool is equipped with three broad faced chuck jaws, graduated guide posts and large winghead thumb screws to provide accurate centering of the tool on the pipe. It is supplied with a 24-inch steel handle.

Motor Starter

CUTLER-HAMMER, INC.

Design improvements in its across-the-line starter for control and protection of polyphase squirrel cage motors up to 5 horsepower have been announced by Cutler-Hammer, Inc., 315 North 12 Street, Milwaukee.

The cover has been changed to a hook-on type held by one fastening screw which can be removed for easy installation. It is designed to permit group panel mounting with minimum clearance between adjacent starters, and the interior of the case is finished in light aluminum to facilitate wiring and inspection in poorly illuminated locations.

Cutler-Hammer Across-the-Line Starter

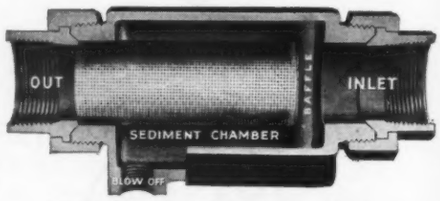
Loosening one screw permits removal of the operating mechanism for easy wiring and conduit work. The contacts are made of heavier fine silver. Lava insulators protect contact springs against heat transmission to insure full contact pressure at all times. The contact springs and contact supports are made of stainless steel, while other metal parts are cadmium plated. The over-load relay has been made smaller and more accessible.

The starter is available with reset only for 2- or 3-wire remote control, with start and stop buttons for 3-wire control, and with three position selector switch for manual-off-automatic local control or 2- or 3-wire remote control. Enclosures include general purpose, water-tight, dust-tight and Class I-D or II-G. The starter is also available in open panel type for cavity or built-in mounting.

Strainer

WRIGHT-AUSTIN COMPANY

A new strainer, designated Easyclean, for use on steam, oil and compressed air lines to power and industrial equipment and designed to prolong the life of steam traps, pressure reducing valves and similar units, has been announced by Wright-Austin Company, 315 West Woodbridge Street, Detroit.



Wright-Austin's Easyclean Strainer

The unit is connected as a union in a pipe line, and has a pocket designed to collect dirt and scale before reaching the screen. The screen is perforated sheet brass having 400 1/32-inch holes per square inch, and the body is cast semi-steel designed for working pressures up to 250 pounds.

It is available in ½-, ¾-, 1-, 1¼-, 1½- and 2-inch sizes.

Boiler Covering

ACHESON COLLOIDS CORPORATION

A new surface treatment designed to prevent or minimize corrosion of furring of boilers has been announced by Acheson Colloids Corporation, Port Huron, Michigan.

The coating, which may be applied by dipping, brushing or spraying, includes colloidal graphite, an electropositive metallic filler, a hardenable organic colloid and a hardening agent for the colloid, all suspended in water.

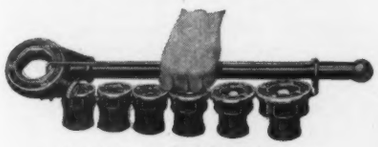
It may be applied at normal temperatures, or, if faster drying is desired, at around 100° C. After application, exposure to light, natural or artificial, hardens the organic colloid to provide a corrosion-resistant coating with a relatively high degree of resistance to abrasion.

Threaders

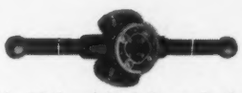
THE RIDGE TOOL COMPANY

Three new ratchet and 3-way threaders for small pipe have been announced by The Ridge Tool Company, Elyria, Ohio.

Nos. OOR, OR and 11R are of all-steel malleable alloy and thread ⅛- to 1¼-inch pipe. Separate sets of semi-high-speed tool steel chaser dies may be removed for regrinding. In No. OOR, die heads are locked in or removed by a pull of the ratchet knob. In Nos. OR and 11R, die heads push out for changing. The tool is designed so no special dies are needed for threading pipe close to wall as it is only necessary to turn dies upside-down and shift to positions marked on die heads. A carrier which holds the rachet ring and set of dies is supplied with all complete sets.



No. OR and 11R RIDGID Ratchet Threaders for ⅛" to 1¼" pipe.



No. 30-A and 31-A 3-way Ratchet Threaders for ⅜" to 1" pipe.

The Nos. 30A and 31A 3-way threaders for small pipe have virtually the same features. They have double ball-end handles and thread pipe from ⅜- to 1-inch.

Valve

MANNING, MAXWELL & MOORE, INC.

A 600-pound standard steel valve designated Hancock Duravalve Junior and featuring a Stellite seat welded integral to the body, has been announced by Manning, Maxwell & Moore, Inc., Hancock Valve Division, Bridgeport, Connecticut.

The integral seat construction is designed to eliminate chance of leakage between seat ring and body as there are no threads to leak. The valve disc is heavily Stellited to resist wire-drawing and wear. The body and bonnet are of carbon Molybdenum steel, giving a temperature rating of 950° F. at 600 pounds steam pressure.

The valve is available in sizes ¼- to 1-inch, in the globe type, with either screwed or socket welding ends.

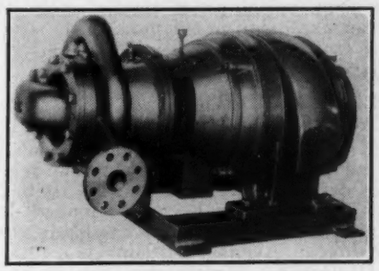
Hancock Duravalve Junior

Multi-Stage Pump

ALLIS-CHALMERS MANUFACTURING COMPANY

Addition of a two-page pump with 4-inch suction and 2-inch discharge, rated up to 275 gallons per minute against heads up to 500 feet at a speed of 3550 rpm to its series of SS Unit pumps, in which the motor and pump housings are bolted together for compactness, has been announced by Allis-Chalmers Manufacturing Company, Milwaukee.

The pump has cast iron casing and cover and is bronze-fitted throughout. Impellers are placed back to back to



Allis-Chalmers' Two-Stage Pump

Leading Refiners Use This

FASTER • CHEAPER • BETTER

Way to Clean Tubes

We've been selling tube cleaners to Refineries long enough to know better than to make claims that we can't make good. Here are facts which you can verify. The new Rapid Action Roto Guns are cleaning tubes in leading refineries up to 30% faster, and in some cases up to 66% faster, than old type guns. Features found exclusively on Roto Guns often save enough on time, labor and compressor operation to pay for the entire gun equipment on the first cleaning job. Let us prove it in your plant.

Only ROTO Guns Can Offer Refiners All These Features

- ★ **make more effective use of air consumed, without developing back pressure;**
- ★ **develop unbelievable speed and power, through new design;**
- ★ **air valve directly behind the motor permits one-man operation;**
- ★ **self-feeding cage and swing-frame heads, universal joints and drills have what it takes to do a real job;**
- ★ **available for straight and curved tubes ½" to 12" I.D.**

Rapid Action Air Valve
Permits One-man Operation

SEE OUR ADV. IN SWEET'S AND WRITE

The ROTO Company

145 Sussex Ave. Newark, N. J.

provide axial balance, and the cover can be taken off to permit the inside parts to be removed without disconnecting the suction and discharge piping. The stuffing box is only subjected to suction pressure.

The unit can be furnished with either an open, splash-proof totally enclosed, or an explosion-proof motor.

Coated Valves

MERCO NORDSTROM VALVE COMPANY

A coating process to permit a lubricated plug cock valve to handle services where temperatures run as high as 1000° F. has been announced by Merco Nordstrom Valve Company, 400 Lexington Avenue, Pittsburgh.

Designated Merchrome, the process employes a welded alloy coating applied to the rotating surfaces of the plugs and bodies, and in some cases other parts of the valves. The coating, having a hardness of 54 on the Rockwell C scale, is described as being corrosion-resistant and having a low coefficient of friction.

For high-pressure service, the plugs of the valves are lapped under heat into the bodies at the temperature corresponding to the service for which they are intended. This step is to provide a means of securing an accurate fit between the plugs and bodies at the operating temperature, and to insure smooth operation. The valves are tested before shipment with hot oil at temperatures up to 600° F., and under pressures equivalent to the intended operation pressure.

The Merchrome-coating has been factory and field-tested for the past two years.

Merco Nordstrom's Merchrome-coated valve, showing coated plug at left before machining, and at right after machining, with plug body in the center.

Welder

ERGOLYTE MANUFACTURING COMPANY

A new welder, featuring all controls and sockets in full view on a sloped panel to eliminate the necessity of crouching or squatting to select heats or make adjustments, has been announced by Ergolyte Manufacturing Company, 3644 Lawrence Street, Philadelphia. The panel provides means for selecting heats in gradual steps over a wide range proportioned to correspond to commercial gauges of metal handled.

With insulation of double spun glass, the welder employs a broken wave current produced by a special winding designed to make it stable and quiet in operation regardless of how unsteadily the electrode is held, providing smooth uniform beads and fillets free from undercutting.

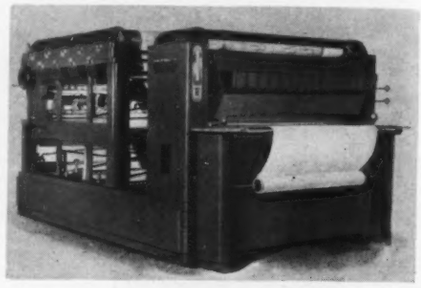
Current required never exceeds 50 wats. The welder is supplied in two models, 160 with a current range of 15-160 amperes, and 250 with a current range of 15-250 amperes. It operates on single-phase, or one phase of two- or three-phase current, and is furnished with helmet, rubber-covered cables, electrode holder and assorted sizes of electrodes.

Blue Print Machine

THE C. F. PEASE COMPANY

A new blue printing, washing and drying machine, designated Model 22, has been announced by The C. F. Pease Company, Chicago.

The machine utilizes arc lamps controlled through a new switch arrangement that permits them to operate at any one of three speeds, as desired. The



Pease Model 22 Blue Printer

washer comprises three horizontal water tanks upon which the paper floats as it is washed. The action is described as eliminating tension wrinkles and distortion. Nine aluminum drums are used to dry the paper. Potash and hypo application is interchanged by a lever control.

Capacity of the machine is rated at 24 linear feet per minute on D. C. current and 18 linear feet on A. C. current for large tracings.

Industrial Truck

ELWELL-PARKER ELECTRIC COMPANY

A power industrial truck sufficiently narrow to enter and maneuver within a boxcar has been announced by Elwell-Parker Electric Company, 4205 St. Clair Avenue, Cleveland. The unit has a 2000-pound rated capacity, can turn corners on a 46-inch radius and travels 5 miles an hour under load.

Elwell-Parker's Industrial Truck

for

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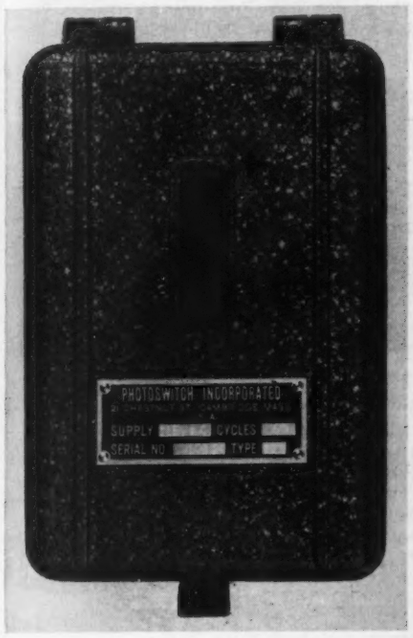
Liquid Level Control

PHOTOSWITCH INCORPORATED

An instrument to provide automatic level control of liquids of any electrical resistance without use of float switches has been announced by Photoswitch Incorporated, 21 Chestnut Street, Cambridge, Massachusetts.



Photoswitch Control

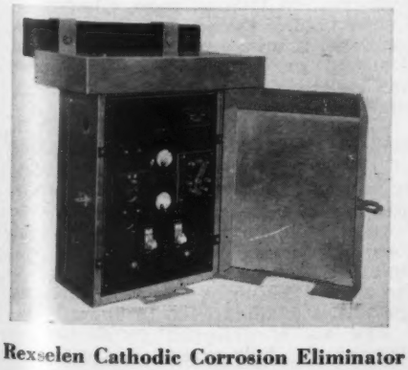
The device is activated by a pair of probes placed in the liquid at the level where the control is desired. Current passing through the liquid actuates the pilot relay. The electrical resistance between probes, according to the manufacturer, may be as high as 25 megohms, while the maximum current passing through the actuating circuit of the pilot relay is 3/1,000,000 ampere.

Cathodic Protection

ELECTRICAL FACILITIES, INC.

A cathodic corrosion eliminator designed for pipe protection and embodying selenium rectifier stacks has been announced by Electrical Facilities, Inc., 4224 Holden Street, Oakland, California.

Designated Type CB Rexselen corrosion eliminator, the unit has no moving parts, cooling fans nor blowers. One unit is rated at 8 volts, 50 amperes DC and is for operation on single-phase AC current supply. It measures 28 inches high, 21 inches wide and 15 inches deep, and weighs 110 pounds. It may be adjusted by transformer taps to a DC output as low as 0.7-volt. Other units are available in capacities from 20 to 200 amperes.



Rexselen Cathodic Corrosion Eliminator

The control panel is equipped with AC magnetic circuit breaker with time delay, ammeter and voltmeter, tap changing link switch, and solderless DC terminals. The eliminators feature a Thermotrol for protection against damage from overloading or operation in abnormally high air temperatures. They are built as a unit and mounted in a ventilated weatherproof steel cabinet designed for out-door mounting on a pole or wall. Indoor models are also furnished.

Flow Switch

McDONNELL & MILLER

A new flow switch employing a positive mechanical action to start a pump, an alarm or any electrical device when flow through a pipe starts or stops has been announced by McDonnell & Miller, Wrigley Building, Chicago.

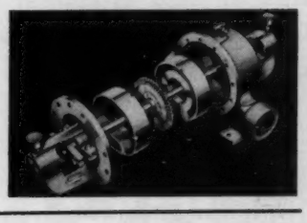
Designated Model E-1, it consists essentially of a long flexible paddle which is extended into the pipe. When the paddle is forced back by the flow in the pipe, it closes an electric circuit and thus starts whatever machinery or valves the switch controls. When flow through the pipe stops, the paddle returns to normal position, breaking the electric circuit. Reverse-acting switches are available, breaking the electric cir-

Westco PUMPS . .

24 HOURS A DAY SERVICE AT TAXMAN OIL CO.

CONTINUOUS OPERATION at Taxman's refinery . . . *and not one cent for repairs!* That's the proven performance record for the two Westco Pumps installed in this progressive Illinois plant. These compact units replaced steam pumps of similar capacity and were selected because of the uniform pressures delivered by Westco Turbine-Type equipment! Our engineers will be glad to consult with you regarding pumps to meet your specific requirements. Capacities to 420 G.P.M. Facts upon request.

And only Westco Pumps have patented, renewable liners (see right) which protect pump casing against wear . . . enables performance changes to be made merely by switching impellers and liners. This feature also permits standby protection at about one-third the usual replacement cost.



MICRO-WESTCO, INC., 43008 State St., Bettendorf, Iowa

Gentlemen: We are interested in additional information covering Westco Turbine-Type Pumps for the refining industry. Please send literature at once . . . no obligation to us.

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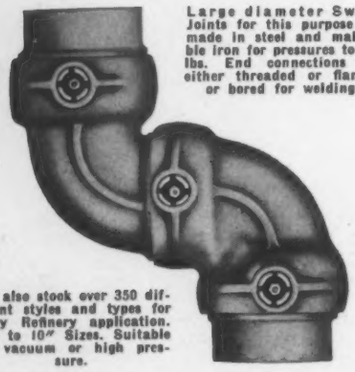

Large diameter Swing Joints for this purpose are made in steel and malleable iron for pressures to 300 lbs. End connections are either threaded or flanged or bored for welding.

We also stock over 350 different styles and types for every Refinery application. ¼" to 10" Sizes. Suitable for vacuum or high pressure.

NO TIGHTENING OR ADJUSTMENT REQUIRED

No packing glands, no nuts and bolts, no sleeve flanges to keep tight when you use Chiksan *Ball-Bearing* Swing Joints. They do not stick or bind in coldest weather. Internal seal is liquid, vapor and gas-tight.

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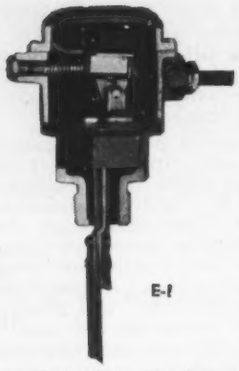
CHIKSAN OIL TOOL CO., LTD.

FULLERTON, CALIFORNIA



McDonnell & Miller's Flow Switch

cuit when flow starts and completing it when flow stops.

The paddle will pass stones and debris, and will not interfere with high rate flows. It can be cut to any length to fit every size of pipe. The paddle arm is connected to the electric switch through a flexible metal bellows to keep the switch waterproof. Tension of the paddle can be varied by an adjusting spring. Top cover of the switch is removable to provide access to all moving parts.

Sheet Packing

GREENE, TWEED & COMPANY

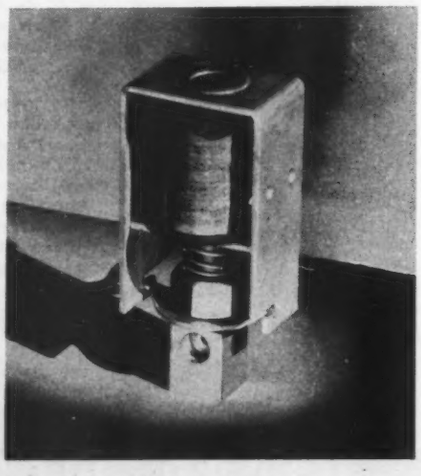
A new compressed asbestos sheet packing, employing long-fibre asbestos and produced in uniform thickness, has been announced by Greene, Tweed & Company, 101 Park Avenue, New York.

The packing is designed as an all-purpose flange and joint packing for superheated and saturated steam at high pressures and high temperatures. It is recommended for packing against air, ammonia, gases, oils, gasoline and most chemical solutions.

Solenoid Valve

GENERAL ELECTRIC COMPANY

A new solenoid valve designed for general applications in the control of air, oil, water and gas has been introduced by General Electric Company, Schenectady, New York. It is designed for incorporation in an assembly that has its own enclosure, and no coil cover or conduit plate have been provided.

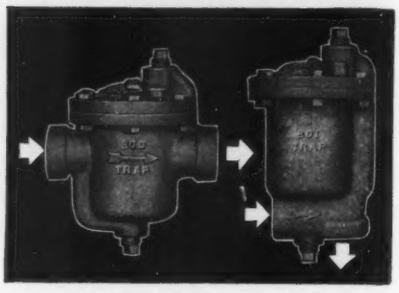


G-E Solenoid Valve

Steam Traps

ARMSTRONG MACHINE WORKS

Two new steam traps, built with more metal at connecting points than models they supersede and designed to permit freer flow of water through redesigned cross-section water passages, have been announced by Armstrong Machine Works, Three Rivers, Michigan. They have one-piece stainless steel buckets, with a single casting size for both ½- and ¾-inch connections.



Armstrong Steam Traps

Model 800 is for use on straight-through pipe connections, and Model 801 for standard angle connections. They may be equipped for blast trap service by using buckets which have an auxiliary thermic air vent. Both traps have an inverted bucket operating principle, free-floating valve mechanisms, self-scrubbing action, heat-treated chrome steel valve seats and stainless steel valve levers.

Proportioner

COCHRANE CORPORATION

An air-actuated proportioner designed for feeding sulphuric acid in conditioning boiler-feed water has been announced by Cochrane Corporation, 17 Street & Allegheny Avenue, Philadelphia.

A contact meter in series with a cycle controller operates an air compressor inside the proportioner shell when a predetermined flow is reached. The acid is measured into the dilution tank to which dilution water is proportioned by a mechanism designed to prevent abnormal chemical concentration. A special feed-line fitting is provided to supply proper introduction of diluted acid or other fluid into the main flow.

Lock Nut

LAMINATED SHIM COMPANY

A self-contained, one-piece, all metal lock nut has been announced by An-cor-lox Division of Laminated Shim Company, 64 Union Street, Glenbrook, Connecticut. Designated An-cor-lox lock nut, it utilizes a locking principle designed to obtain effective, positive and locking of the nut to the bolt, not to the work.

To apply, the nut is spun on the bolt and drawn up to the desired degree of tightness, where the nut locks itself automatically to the bolt. An arcuate-shaped metal locking ring in the bottom of the nut is expanded by the locking pressure into the root of the bolt thread and against the nut rim. No special length of bolt is required as the nut is adapted even to short bolts.

The nut is designed so as not to damage the bolt thread nor mar the

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Standard RIDGID *No. 1 and 2 Pipe Cutter*

YOU'LL be surprised at the quick easy way this new type cutter wheel rolls through pipe. Its forged blade, assembled in a solid hub, extra-thin and tough, actually cuts more pipe per wheel, saving you money. And cuts true in the powerful smooth-working Standard RIDGID Cutter. Made also in heavy-duty pattern, both cutters and wheels. Save time, work and money with these remarkable cutters. Buy them at your Supply House.

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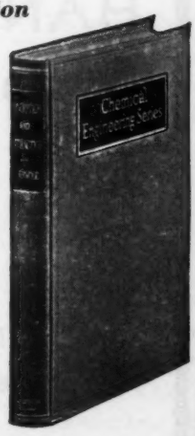
Here's help in the design and operation of absorption and extraction equipment.



ABSORPTION and EXTRACTION

By THOMAS K. SHERWOOD

Associate Professor of Chemical Engineering, Massachusetts Institute of Technology

278 pages — 91 illustrations — $3.50

This book outlines the underlying theory of such important diffusional processes of the unit operations of chemical engineering as absorption, extraction, drying, humidification, and dehumidification. Particular attention is given to the engineering problems connected with the design and operation of equipment for absorption and extraction.

Special Features:

- —chapters on absorption of multi-component mixtures and on solvent extraction.
- —treatment of equilibria in liquid-vapor systems of mixed hydrocarbons.
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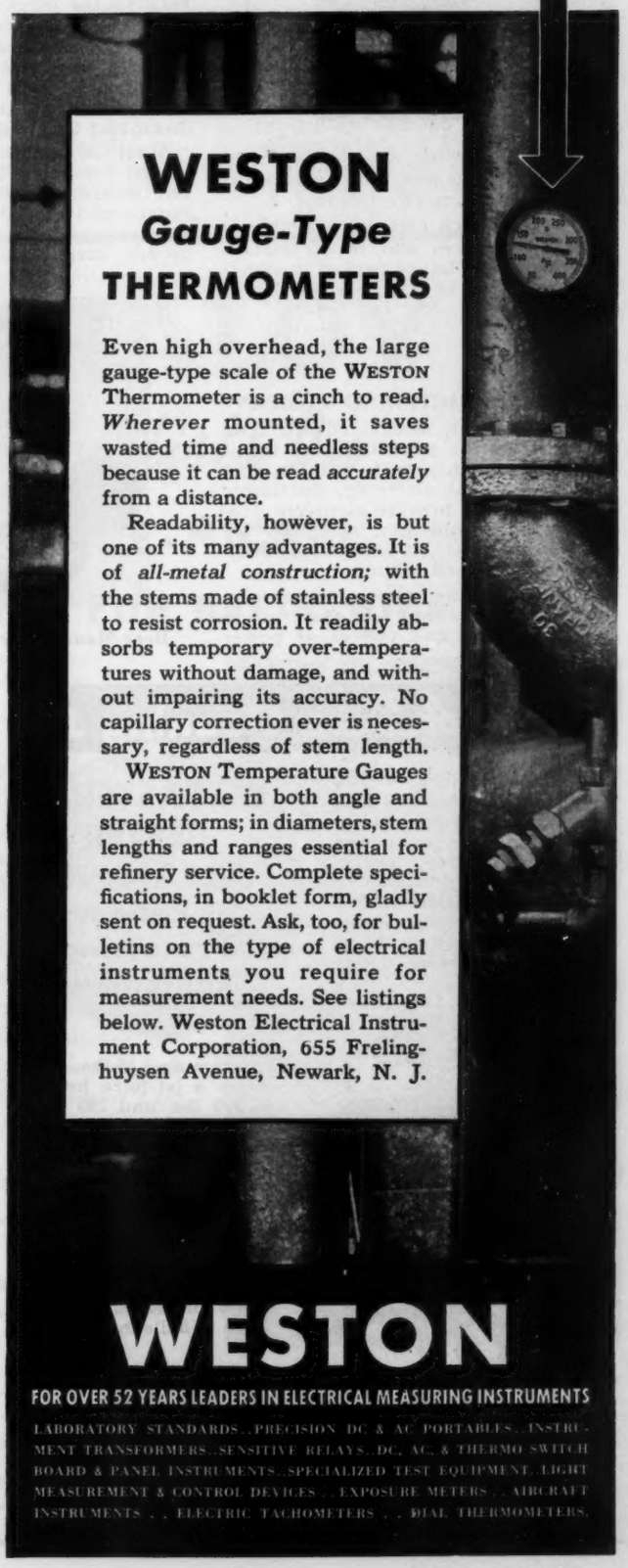

WESTON *Gauge-Type* THERMOMETERS

Even high overhead, the large gauge-type scale of the WESTON Thermometer is a cinch to read. *Wherever* mounted, it saves wasted time and needless steps because it can be read *accurately* from a distance.

Readability, however, is but one of its many advantages. It is of *all-metal construction;* with the stems made of stainless steel to resist corrosion. It readily absorbs temporary over-temperatures without damage, and without impairing its accuracy. No capillary correction ever is necessary, regardless of stem length.

WESTON Temperature Gauges are available in both angle and straight forms; in diameters, stem lengths and ranges essential for refinery service. Complete specifications, in booklet form, gladly sent on request. Ask, too, for bulletins on the type of electrical instruments you require for measurement needs. See listings below. Weston Electrical Instrument Corporation, 655 Frelinghuysen Avenue, Newark, N. J.

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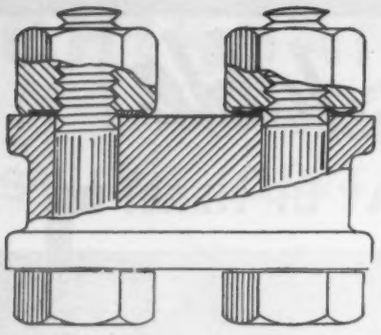


Laminated Lock Nut

surface of the work, and the same nut can be used time and time again without loss of locking effectiveness.

An-cor-lox lock nuts are available in all standard sizes and in all metals. They may be obtained packed in standard packages, or in bulk in larger quantities.

Welder

BEAR MANUFACTURING COMPANY

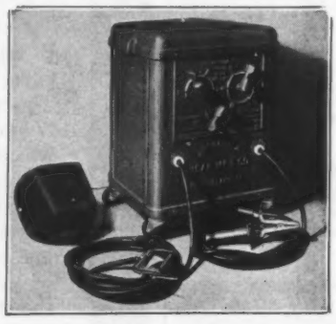
A new welder, designated AC Arcmaster, featuring a multiple-coil transformer design to provide an even flow of current to the electrode, and safety construction to provide complete protection of the operator, has been announced by Bear Manufacturing Company, Rock Island, Illinois.

Four-coil transformer construction with reactance control is designed to level the peaks and valleys of power variation and to make possible a uniform and constant welding voltage with calibrated amperage from lowest to highest output.

Either ground or welding leads can be connected with any of the input wires without completing an electrical circuit, while a circuit on the output cannot be completed until actual welding takes place. There is no connection between the input and the output, providing operating safety.

Transformer laminations are of silicon steel with over-size core and wire to withstand heat created under constant use, to prevent insulation breakdown and to avoid complete burnouts.

Made of heavy cast aluminum designed for rapid heat dissipation, the unit is furnished in three models with ranges of 10 to 200 amperes, 10 to 250 amperes, and 10 to 300 amperes. All models have 220 60-cycle voltages, and each unit includes 20 feet of ground cable, 20 feet of electrode cable, head shield, rod holder and an assortment of rods. All models have been approved by Underwriters' Laboratories.



Bear Manufacturing's AC Arcmaster

Time-Cycle Controller

TAYLOR INSTRUMENT COMPANIES

An instrument for timing the sequence and duration of operations involving temperature, pressure, humidity or combinations of each, designated Flex-O-Timer, has been introduced by Taylor Instrument Companies, Rochester, New York.

The time-cycle controller is designed with adjustable pins on the revolving drum, eliminating cam cutting and permitting adjustment of the actuating pins in circumferential undercut grooves on a one-piece drum, locked in place with a screw. The adjustment is to permit the air valve or switch to be turned on and off within 0.5 percent of the total cycle time.

A latch-type solenoid-operated mechanism starts the process, actuating one or more snap operators to start the high-torque, fan-cooled synchronous timer motor. Outside electrical or pneumatic functions are performed simultaneously at the start of the cycle, while an external push button or limit switch can be used to provide the electrical contact to start this process.

The instrument provides a varying drum speed rotation for processes where the diversity of products being processed requires considerable variation in processing time. The drum is

Sellers *Hi-Pressure* Cleaning Jet

for FASTER, BETTER CLEANING of Refinery Processing Equipment

A PORTABLE cleaning unit for cleaning heat exchanger bundles, cooling coils, bubble caps, pumps and machinery, barrel heads, etc.—providing a cheaper and better method of cleaning. Utilizing steam at a pressure from 50 to 125 lbs. and water at any pressure over 15 lbs., it produces a jet force from 100 to 270 lbs. and 180 to 190 degrees—two to three times the dirt penetrating force and cutting power of fire lines.

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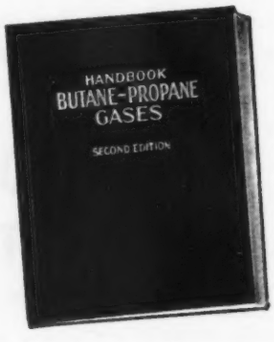

Butane-Propane Gases

SECOND EDITION—(Revised, September, 1938)

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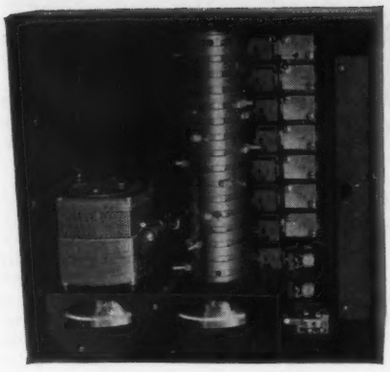


Taylor Flex-O-Timer

directly run by a spur gear train, and a dog-and-latch mechanism provides 78 different drum speeds with each gear train ratio. The drum speed is fixed and positive for any given setting and can vary only as the frequency of the electrical supply changes. Models are also available with a fixed speed gear train.

A new type of low leak air valve is described as utilizing 99.5 percent of the air passed through it, the air valve plunger being so designed that the air supply port cannot at any time communicate with the exhaust port to assure rapid and full air pressure application and release.

Alloy

McKENNA METALS COMPANY

A new grade of Kennametal tungsten-titanium carbide alloy, described as combining hardness with toughness, has been announced by McKenna Metals Company, 224 Lloyd Avenue, Latrobe, Pennsylvania.

The new alloy, known as Kennametal K3H, is designed for a tool-dip material for light finishing cuts and for fairly heavy continuous cuts on steel of all hardnesses up to 550 Brinell. Tool tips of this material are supplied in three standard shapes, or in special shapes made to specification. Tools on which tips have already been brazed are also furnished.

Kennametal K3H has a hardness of 79.0 Rockwell C and a strength of 210,000 pounds per square inch on the transverse rupture test.

Steel Tapes

THE LUFKIN RULE COMPANY

A new line of steel measuring tapes, designated Chrome Face, has been announced by The Lufkin Rule Company, Saginaw, Michigan. Chrome plated with jet black markings and satin chrome-white surface, they are described as being unusually free of glare. Permanent markings stand out in sharp contrast, showing up in poor or artificial light.

A full line of Chrome Face gaging tapes are offered, including the Atlas and other models with plumb bobs of various patterns. Anchor is the brand in leather case.

The tapes are offered graduated either feet, inches and eighths; or feet, 10ths and 100ths, with lines in both ⅜- and ½-inch width. The ½-inch is described as being especially suitable for general measuring in the industry because its greater width gives it extra durability and it accommodates larger figures.

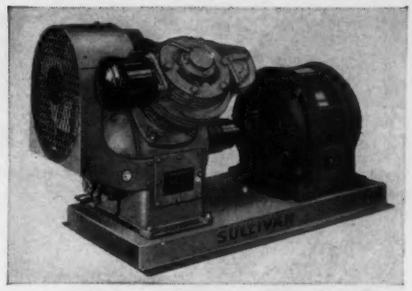
Compressor

SULLIVAN MACHINERY COMPANY

A small stationary compressor, designed for small industries and for standby service and described as compact, light-weight and smooth-running, has been announced by Sullivan Machinery Company, Michigan City, Indiana.

The unit, designated WL-70, is a two-cyclinder, single-stage model with complete air cooling, built-in after-cooler, force-feed lubrication, heavy-duty ball main bearings, low-lift valves and air filter silencers.

The compressor is available in five sizes, ranging from 96 to 233 cubic feet-per-minute displacement, 15 to 30 horsepower, and air pressures from 30 to 125 pounds. It is supplied as a complete motor-driven unit on steel sub-base, direct-connected or V-belt driven, or may be had less sub-base with V-belt sheave or flat belt pulley.



Sullivan's Model WL-70 Compressor

DURALOY

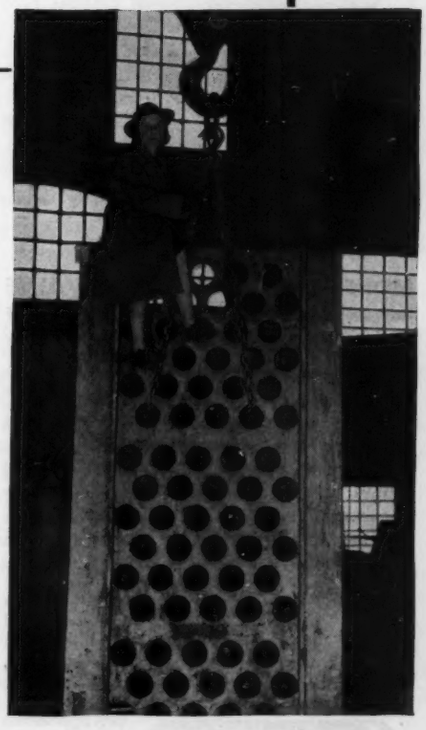
Specialists In

CHROME-NICKEL

CASTINGS FOR REFINERIES

The word "specialists" implies experience in and knowledge of the subject. And if ever a company was a specialist in the chrome-nickel castings for oil refineries, it's Duraloy. The year 1922 marks the beginning of Duraloy service and from its foundry has come many a ton of tube supports, pump castings, liners, safety sleeves, gate valves, dampers, recuperators, baffles, etc. Since 1931 Duraloy Centrifugal Cast Tubing has been on the market. This date, too, implies maximum experience in this important phase of chrome-nickel metallurgy.

The very quality of Duraloy Castings deserves a share of your business.



THE DURALOY COMPANY

OFFICE AND PLANT: SCOTTDALE, PA.

EASTERN OFFICE: 12 EAST 41ST ST., NEW YORK, N. Y.

DETROIT — The Duraloy Co. of Detroit

PHILADELPHIA — Adair-Day Corporation

SCRANTON, PA. — Coffin & Smith

ST. LOUIS — Metal Goods Corporation

LOS ANGELES — Great Western Steel Company

Good-Looking

well-built!

MODEL "WTN-A" SAFETY VALVE
has beauty that comes from simplicity of design and precision and care in manufacture. It is as simple and practical as can be made.

Distinct advantage is its full throat tube seat area for high capacity without restriction of flow. Has reinforced insert bushing within which stress is confined, eliminating a second joint. Can be furnished with or without an adjusting ring. Made in 2, 3, 4 and 6-inch sizes—for air or gas service.

All details of this and other fine products in the LONERGAN LINE fully described in catalog yours on request to J. E. LONERGAN CO., 211 Race Street, Philadelphia, Pa.

Lonergan 300 Specialties for Power Plants — Since 1872

Valves

GAUGES • SPECIALTIES

BUSINESS NOTES

A. H. Borden Heads New Metal Products Company

A. H. Borden heads Borden Metal Products Company, organized with a plant at Elizabeth, New Jersey, to manufacture gratings, safety steps, spiral stairs and special metal floors for refineries, industrial plants and subways.

A. H. Borden

Borden, who has been engaged in the metal grating floor industry for 18 years, said district representatives will be appointed in principal cities.

Henry S. Hall Joins Lukens Steel as Fuel Engineer

Henry S. Hall, former open hearth fuel engineer for American Rolling Mill Company at Middletown, Ohio, has joined Lukens Steel Company, Coatesville, Pennsylvania, as fuel engineer.

A graduate of the University of Pittsburgh with a M. E. degree, he joined Republic Flow Meter Company, Pittsburgh, as district service engineer in 1924, Youngstown Sheet & Tube Company, Youngstown, Ohio, as test engineer in 1926, and American Rolling Mill Company as assistant superintendent of the open hearth division in 1928.

Air Reduction Advances Howard Salisbury and H. B. Seydel

Howard R. Salisbury has been appointed manager of the Philadelphia office of Air Reduction Sales Company. Connected with the company for 15 years, he was manager at Bettendorf, Iowa, for 2 years and assistant manager at Philadelphia for the past 6 years. He is a past chairman of the Philadelphia section of the American Welding Society.

H. B. Seydel, former assistant sales manager of the New York district, has been appointed assistant manager at Philadelphia.

Medart Purchases Reeves Wood Pulley Stock

The Medart Company, Potomac & DeKalb streets, St. Louis, has purchased the wood pulley stock of Reeves Pulley Company, Columbus, Indiana. The latter company has discontinued manufacturing and marketing of wood split pulleys, and its wood pulley dealers and customers will henceforth be served by The Medart Company.

S. Sloan Colt Elected General Electric Director

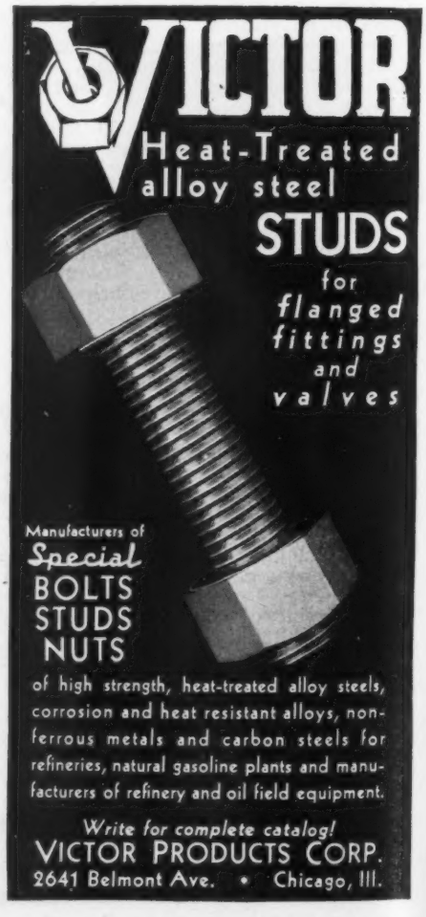
S. Sloan Colt has been elected a director of the General Electric Company, succeeding Seward Prosser, resigned. Colt, graduated from Yale University in 1914, is well known in banking circles, having been a vice president of the Farmers Loan & Trust Company, a vice president of National City Bank and the Bankers Trust Company, and president of the latter organization since 1931. He is a director of various industrial and insurance companies.

Russell Heads Oceco Sales For Johnston and Jennings

The Johnston & Jennings Company, Cleveland, has announced appointment of Murray Russell as sales manager of its Oceco division. For the past ten years, he has been in Bethlehem, Pennsylvania, New York City and Pittsburgh with Byron Jackson Company.

Airco Announces Retirement Of William W. Barnes

Air Reduction Sales Company has announced retirement of William W. Barnes, manager at Philadelphia. He first became associated with the oxy-acetylene industry in 1910 when he joined Davis-Bournonville Company as Philadelphia sales manager. In 1922, when Davis-Bournonville merged with Air Reduction Company, he became the company's manager at Philadelphia.

Grove Regulator Company Opens New Houston Office and Plant

Grove Regulator Company, Oakland, California, has opened new offices and a modern assembly plant at Houston to provide increased engineering and service facilities to companies and supply stores in the Gulf Coast and Mid-Continent areas, according to M. H. Grove, company president. The plant